

# *Vertical Accuracy of SRTM Data of the United States: Implications for Topographic Change Detection*

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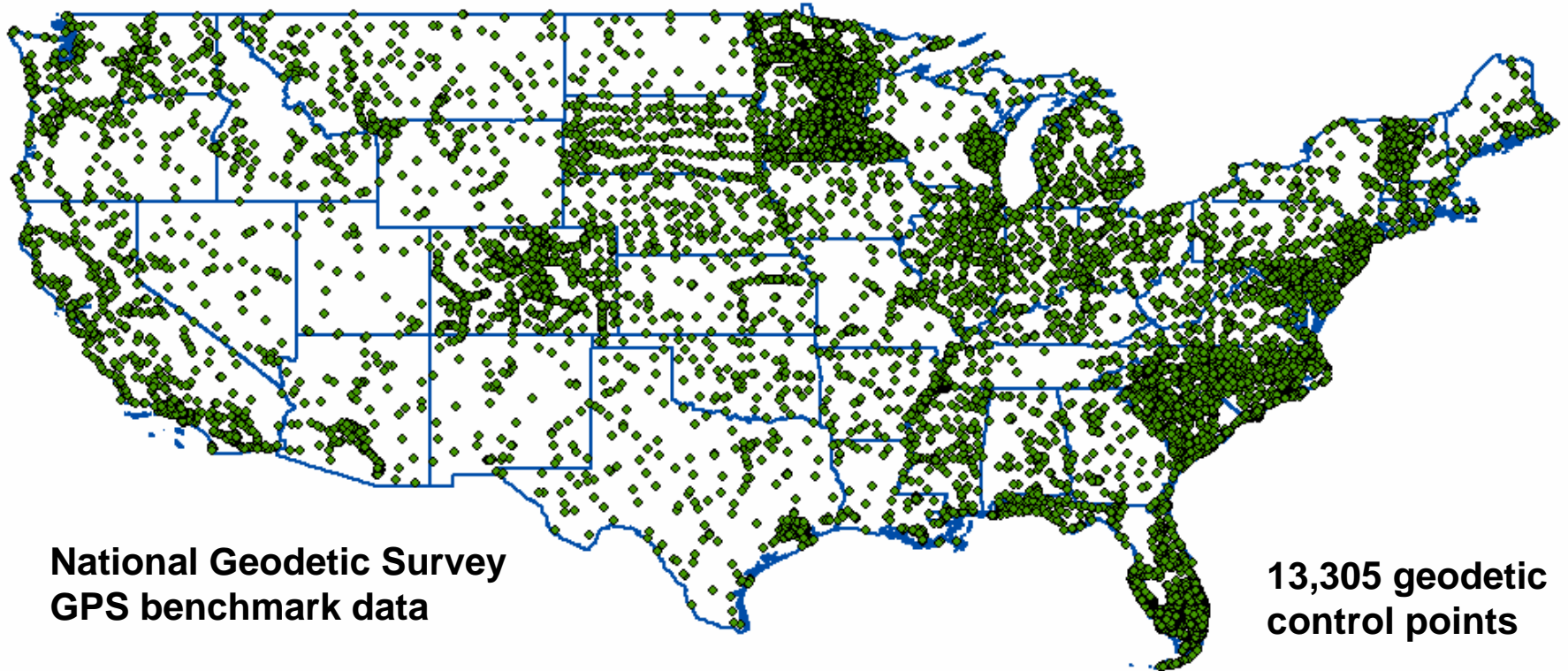
# *Presentation Outline*

- Absolute vertical accuracy of SRTM
  - Error vs. terrain attributes (elevation, slope, aspect, relief)
  - Accuracy by land cover class
- Relative comparison: SRTM vs. NED
  - Terrain attributes and land cover
- An application of vertical accuracy information: topographic change detection

# *Background*

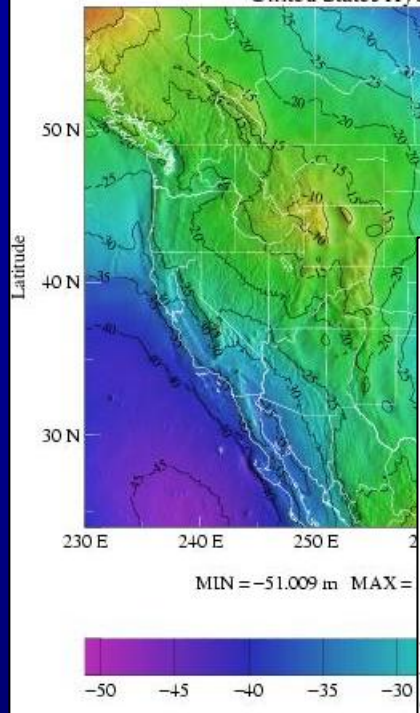
- Commonly asked questions:
  - What is the vertical accuracy of SRTM data?
  - How does SRTM compare with the USGS National Elevation Dataset (NED)?
- Reference data set:
  - GPS on Bench Marks for GEOID03
    - National Geodetic Survey

# *SRTM and NED Accuracy Assessment*

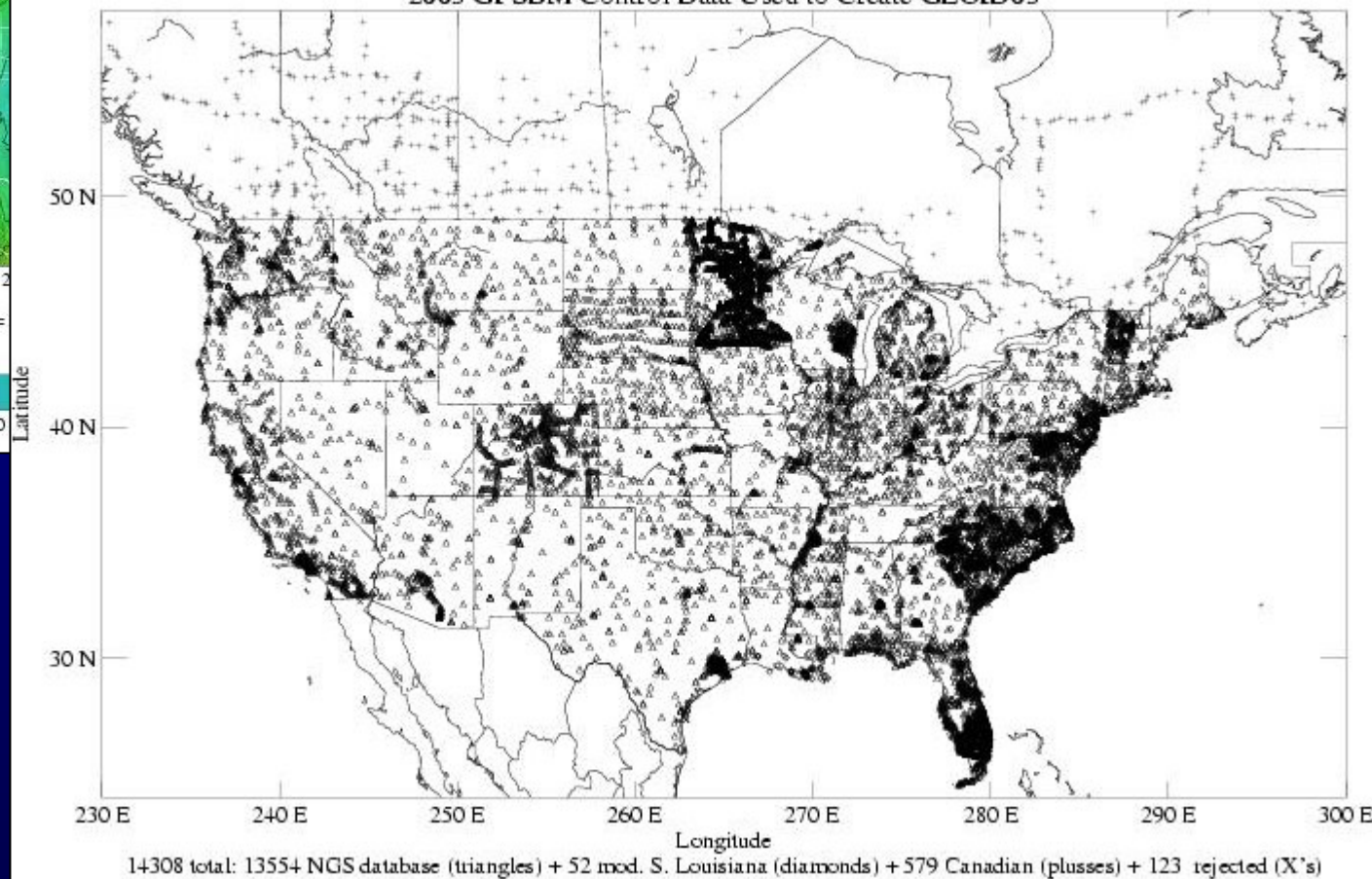


Reference data set for absolute vertical accuracy tests

United States Hybrid Geoid for 2003 (GEIOD03)

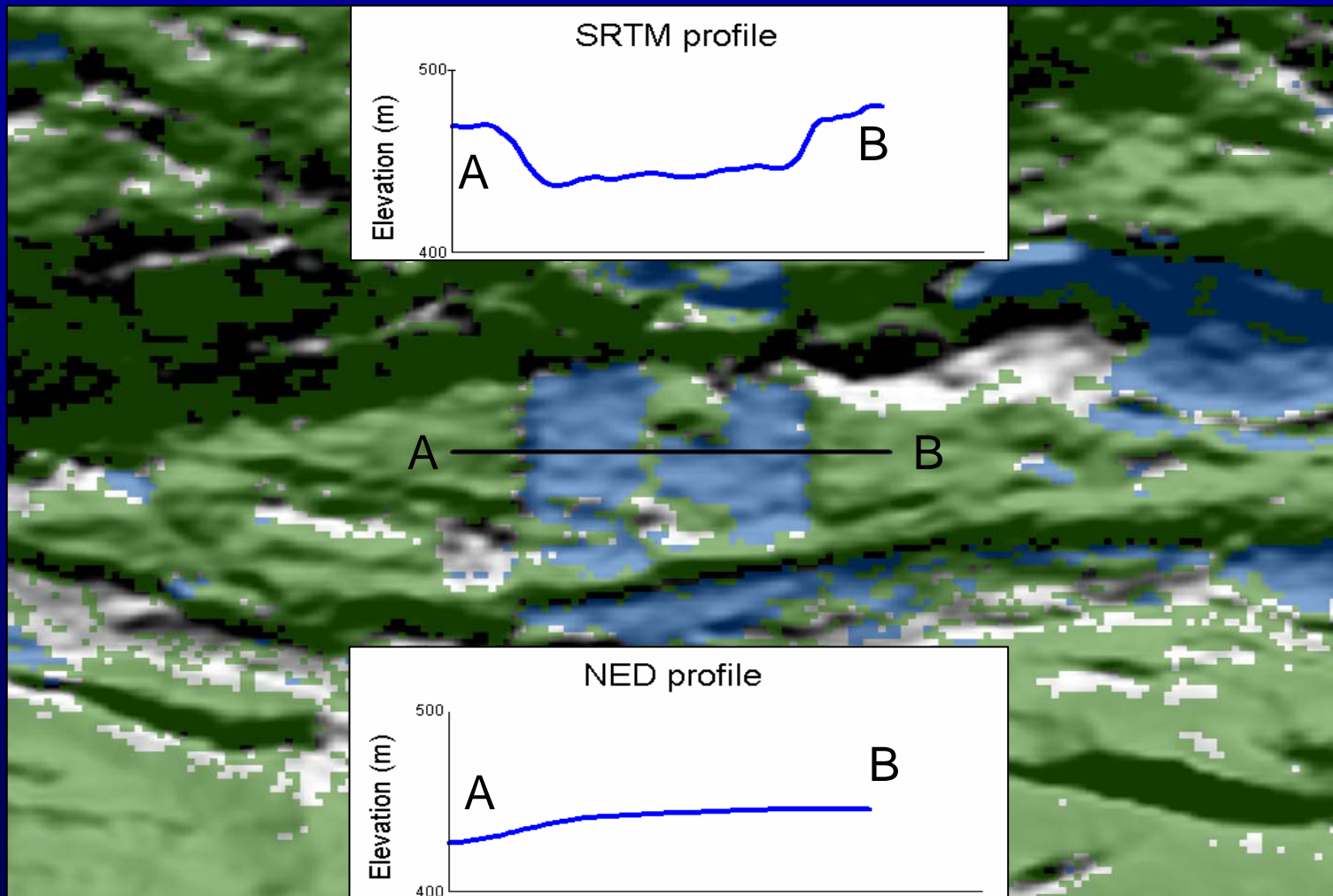


2003 GPSBM Control Data Used to Create GEIOD03

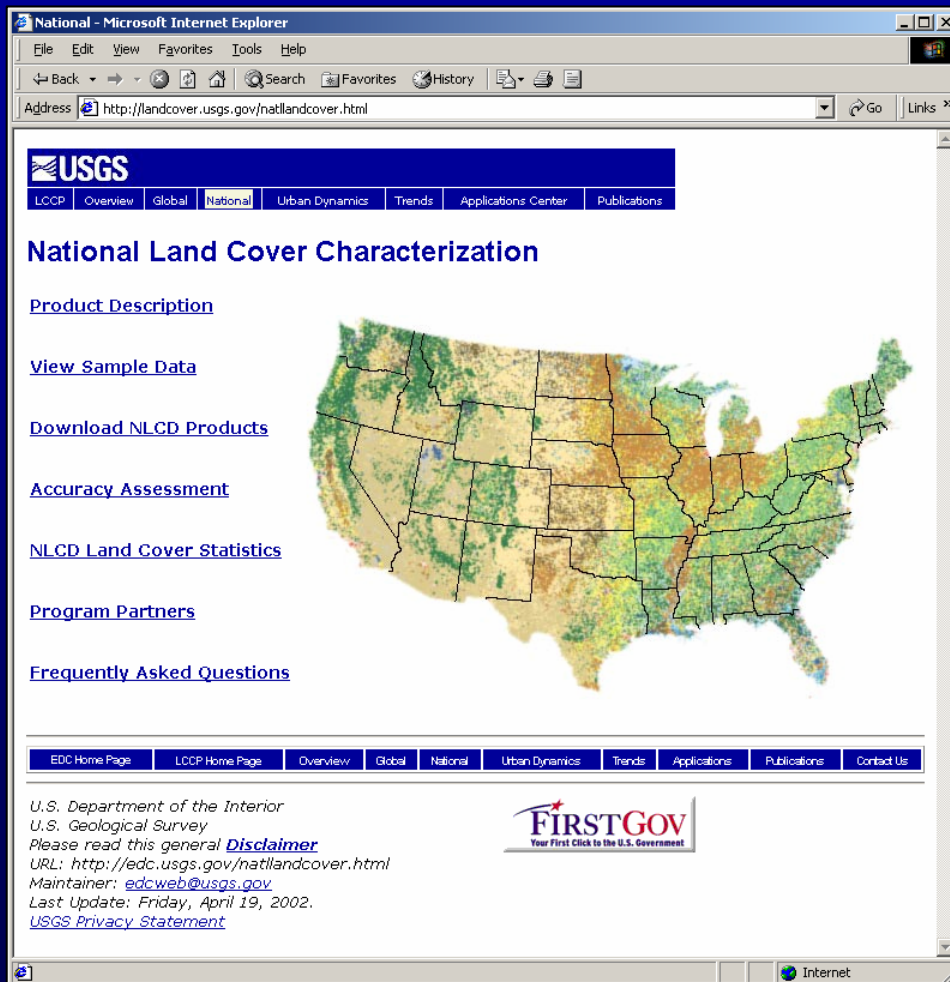




# Land Cover Effects

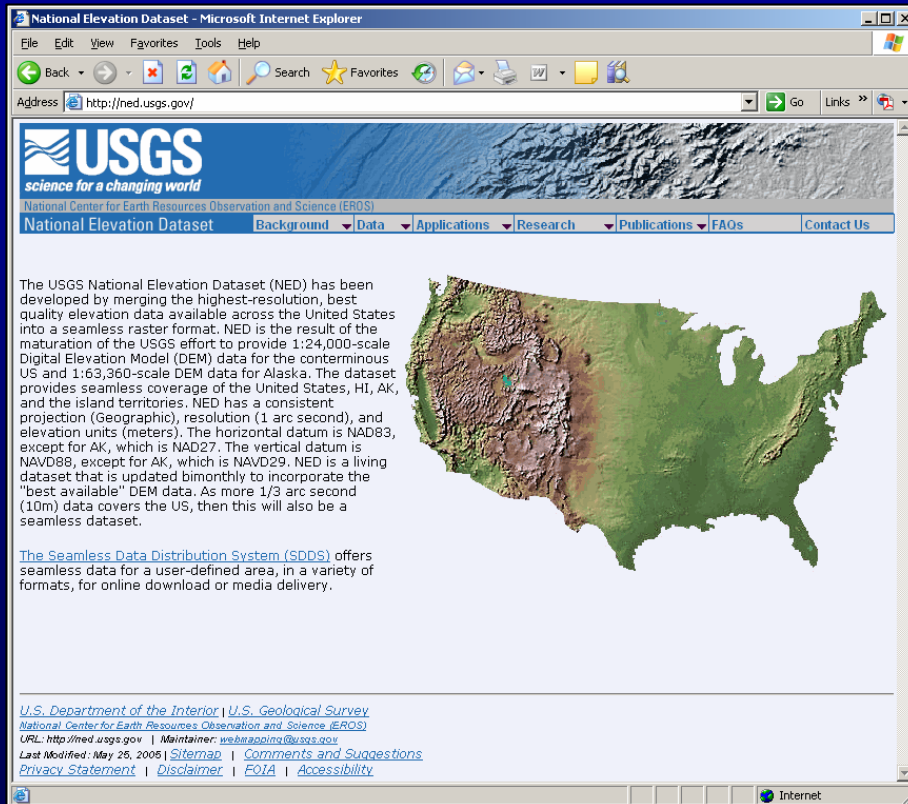


# National Land Cover Dataset (NLCD)



- Seamless land cover data of the United States
- 30-meter resolution
- Source data: 1992 Landsat Thematic Mapper data

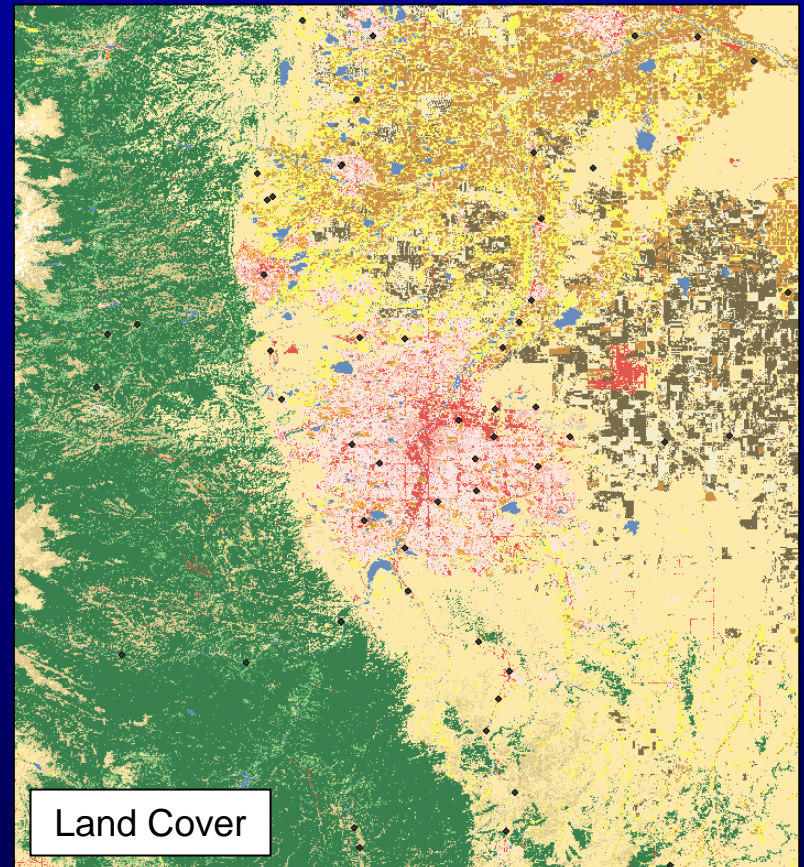
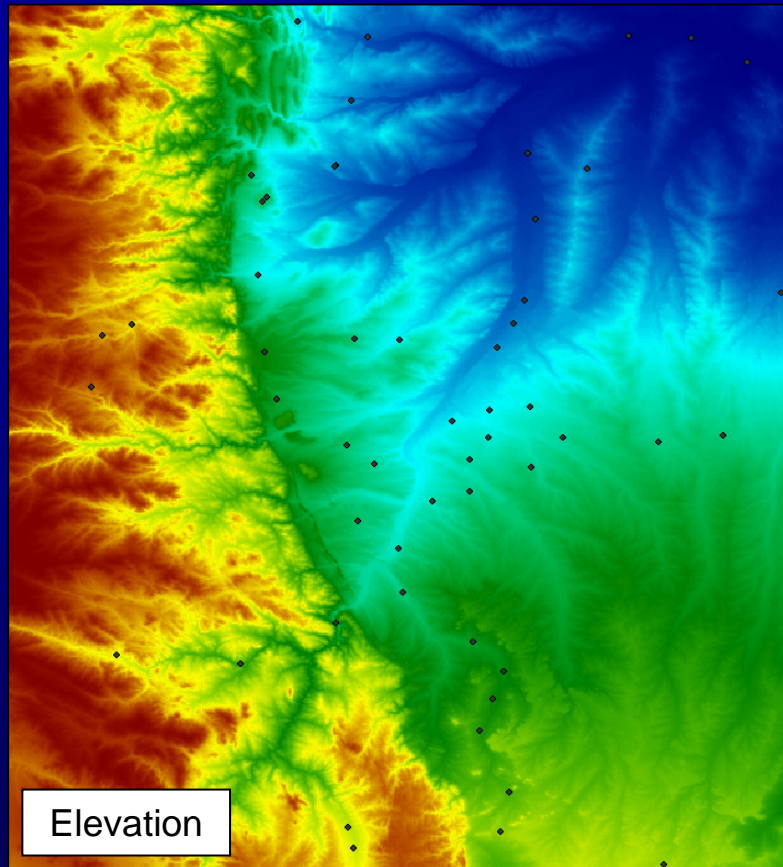
# National Elevation Dataset (NED)



- Seamless “best available” elevation data of the United States
- 1-arc-second resolution
- Source data: over 55,000 tile-based DEMs (10-meter and 30-meter resolution; made from 1:24,000 topographic maps)

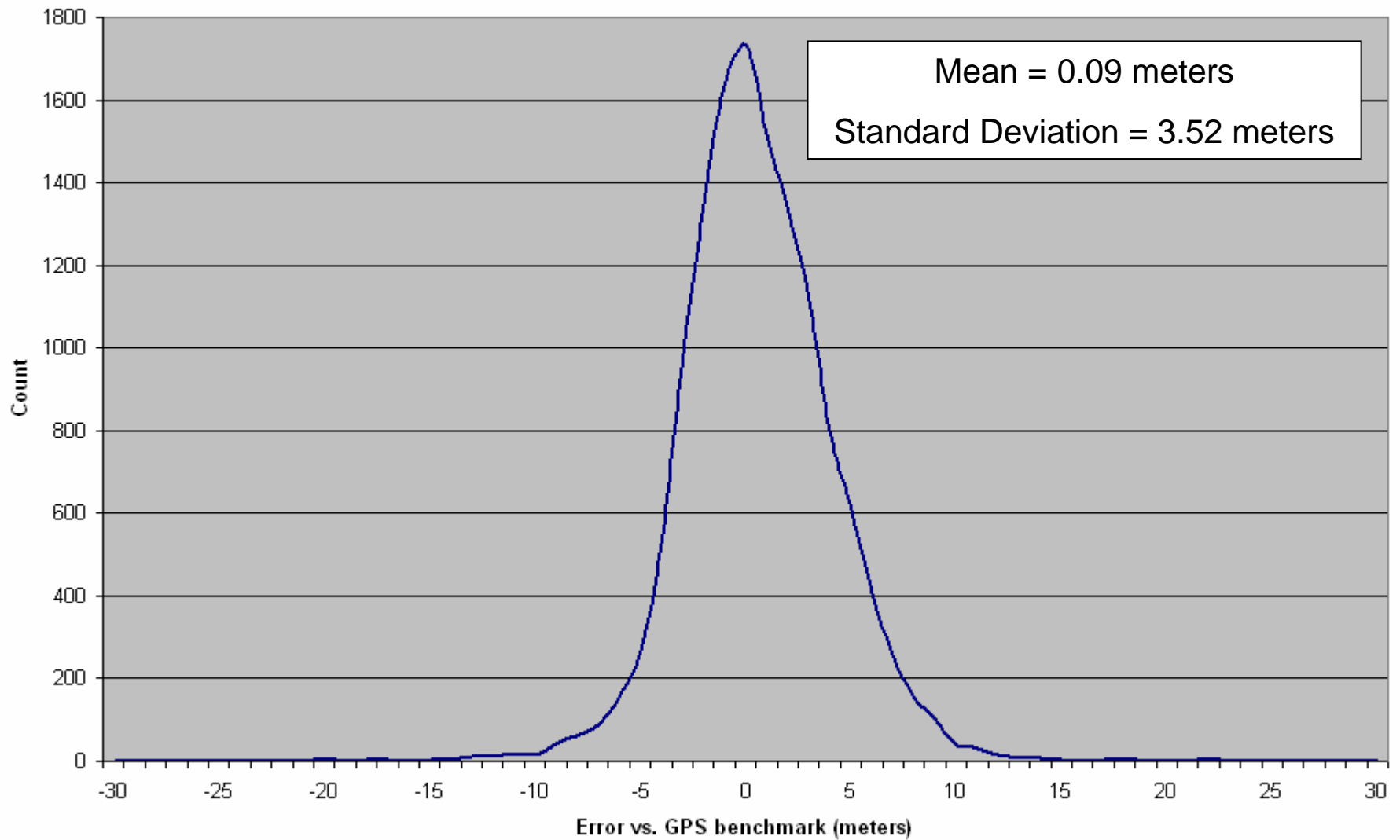


# *SRTM and NED Accuracy Assessment*

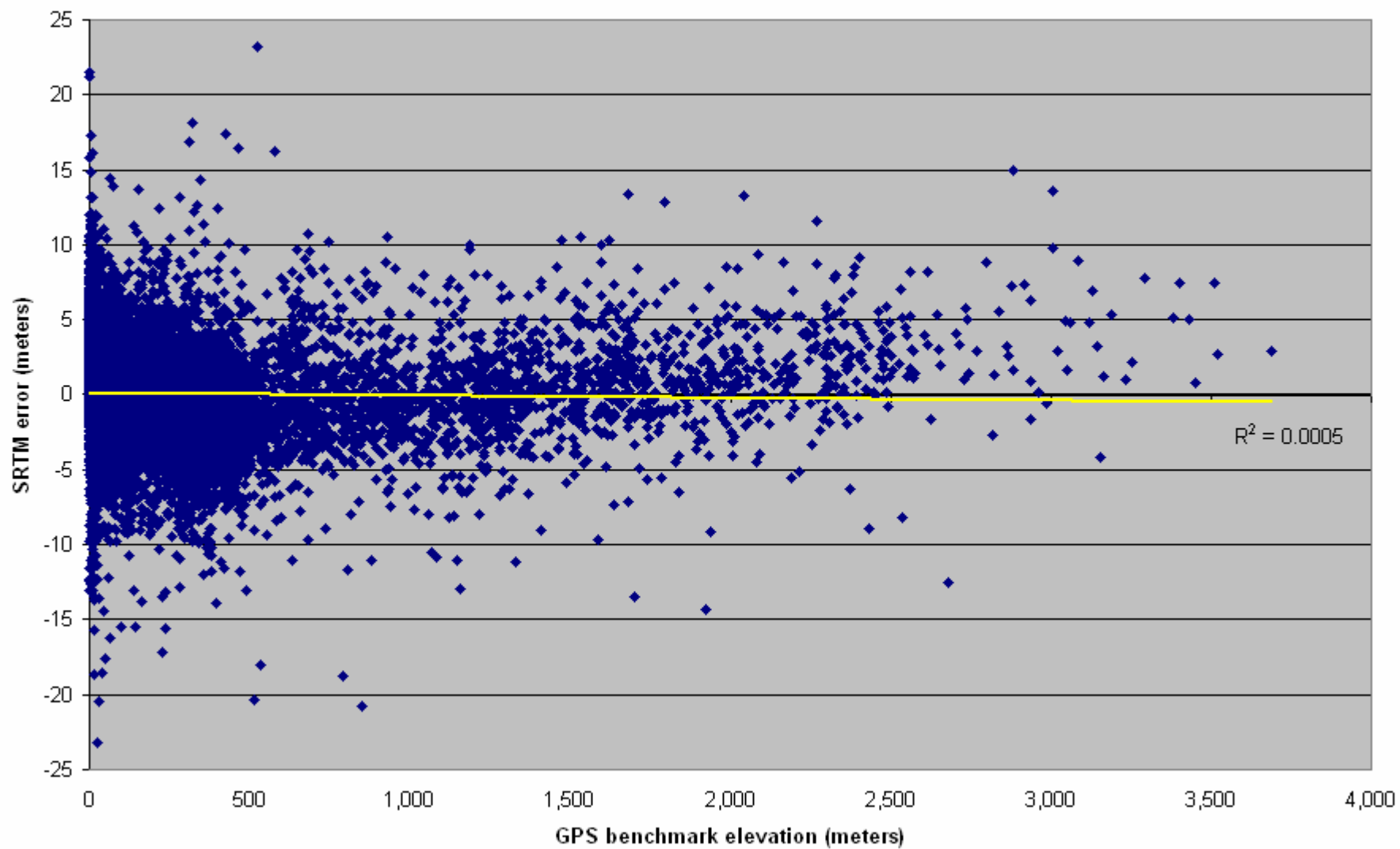


For the 934  $1^{\circ} \times 1^{\circ}$  tiles of SRTM and NED data available for analysis, the GPS benchmark elevation was subtracted from the SRTM and NED elevations, and the NLCD class was recorded

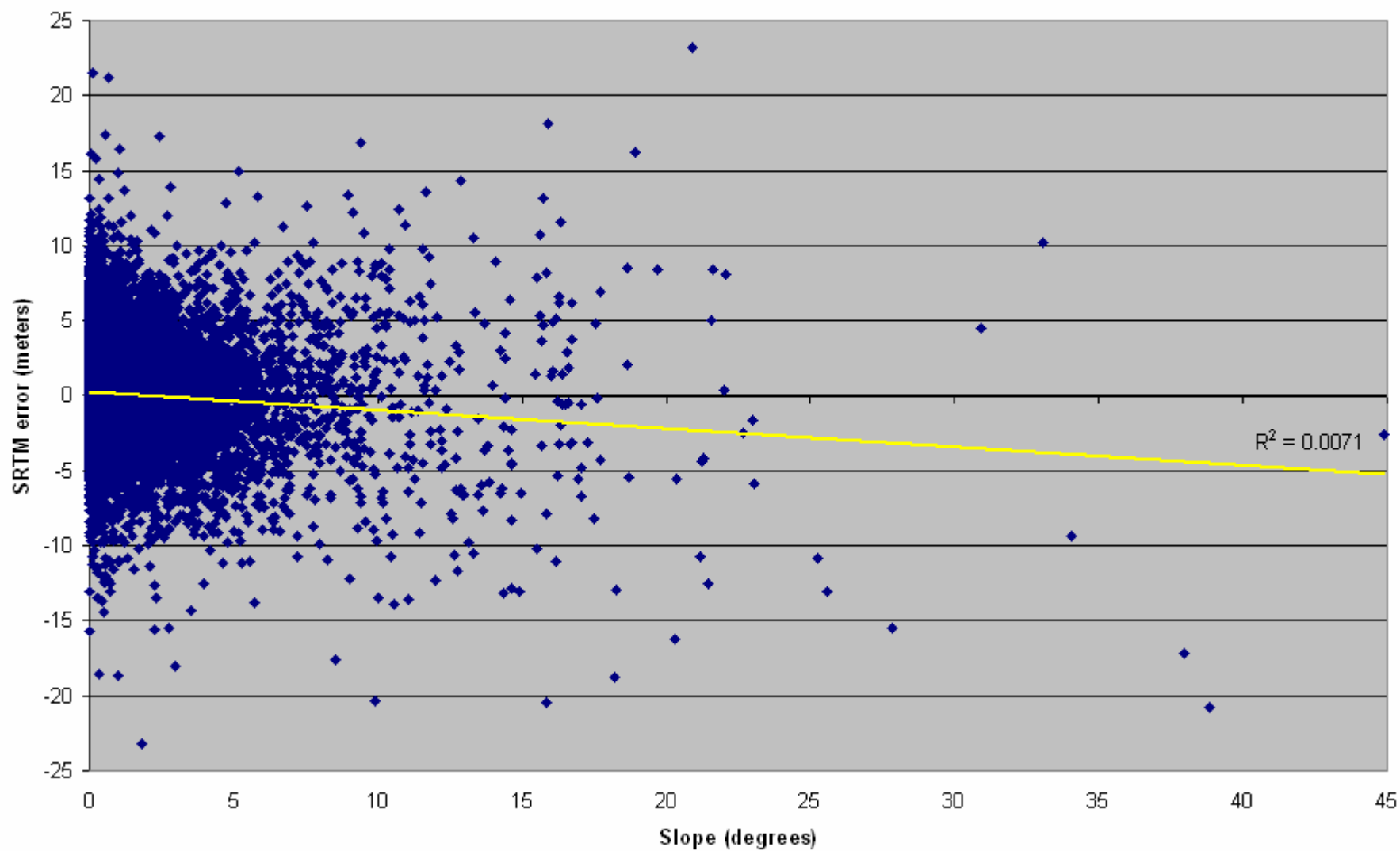
### SRTM Errors



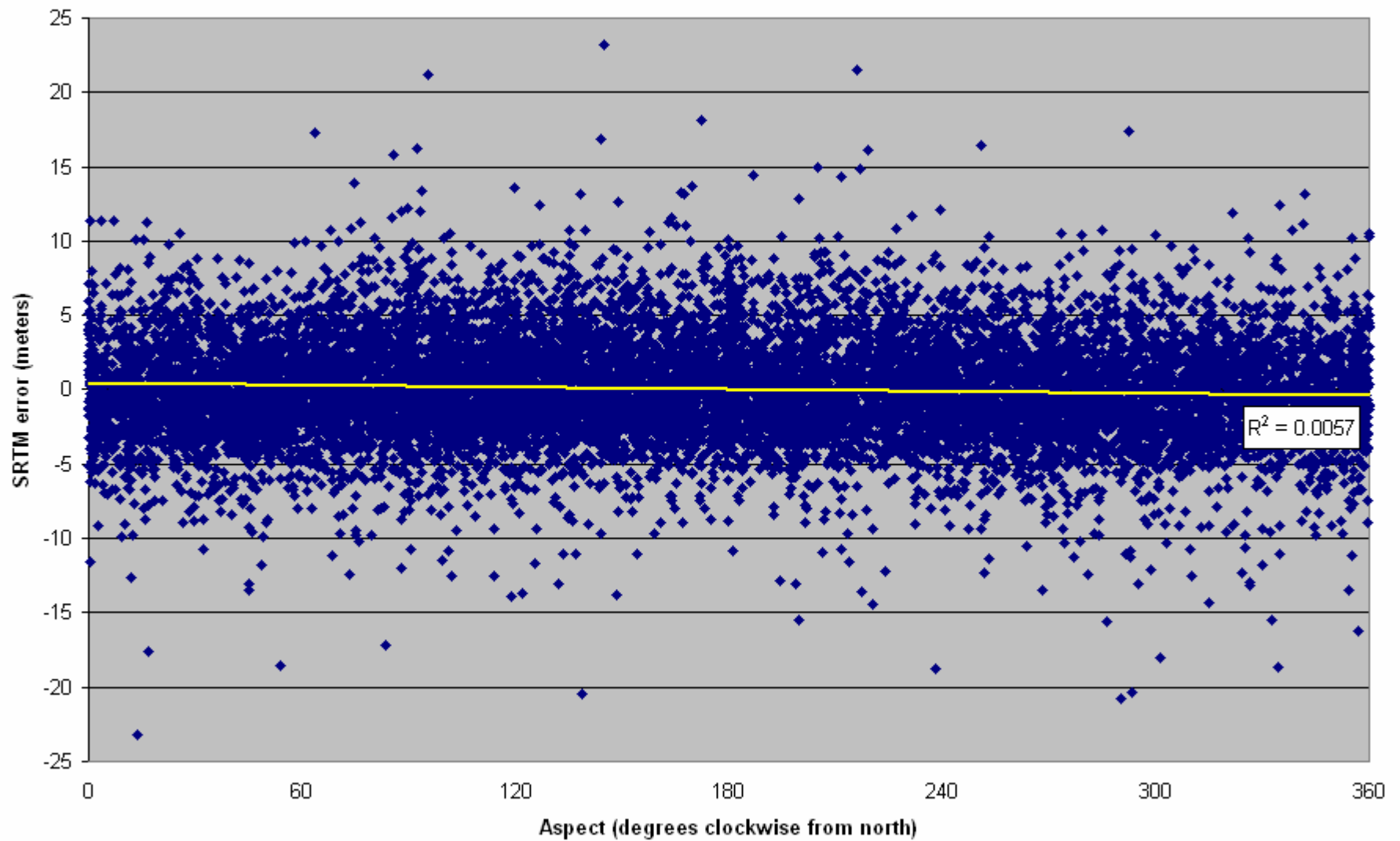
SRTM error vs. GPS benchmark elevations



SRTM error vs. Slope

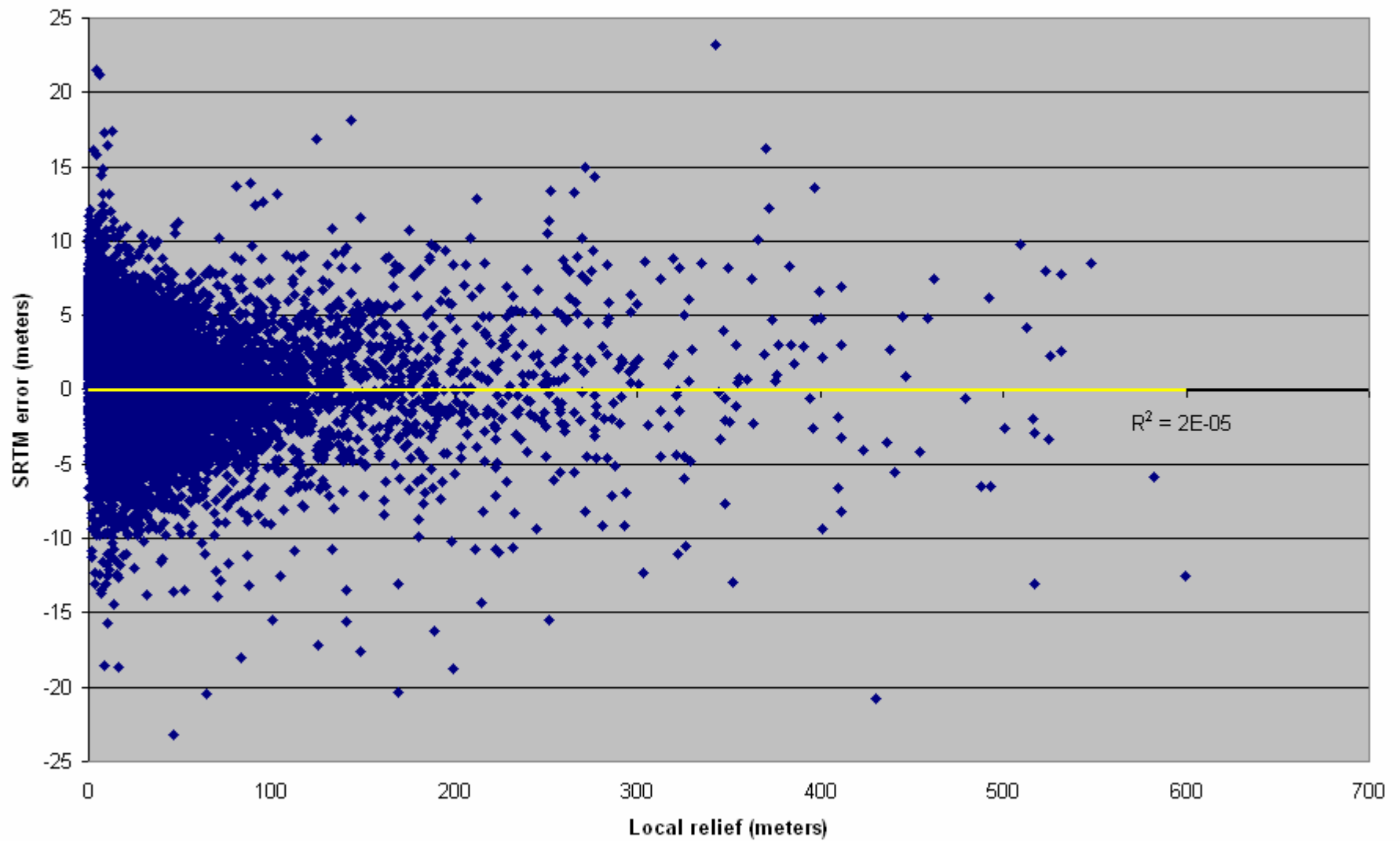


SRTM error vs. Aspect





SRTM error vs. Local relief

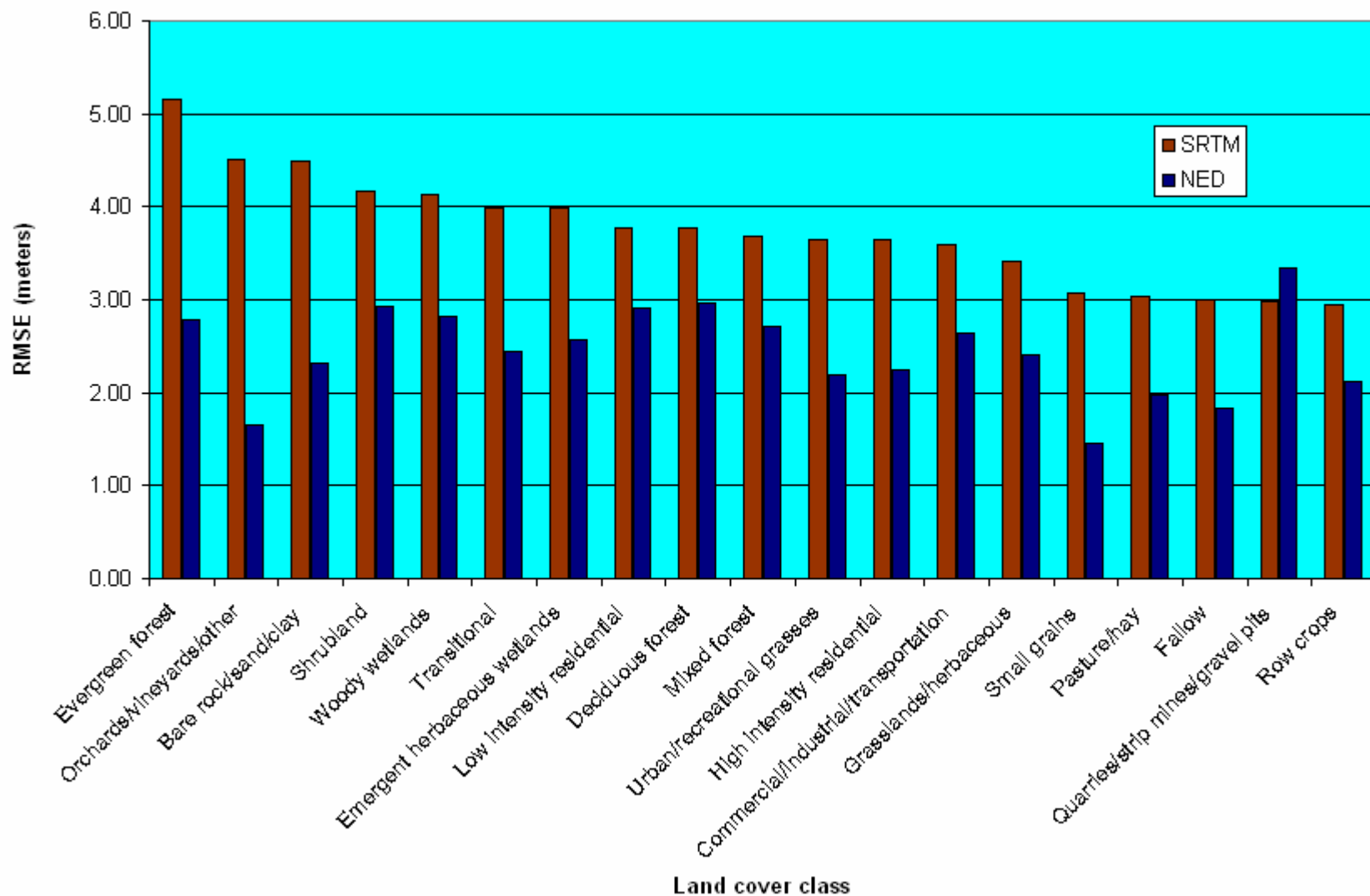


# Absolute Vertical Accuracy

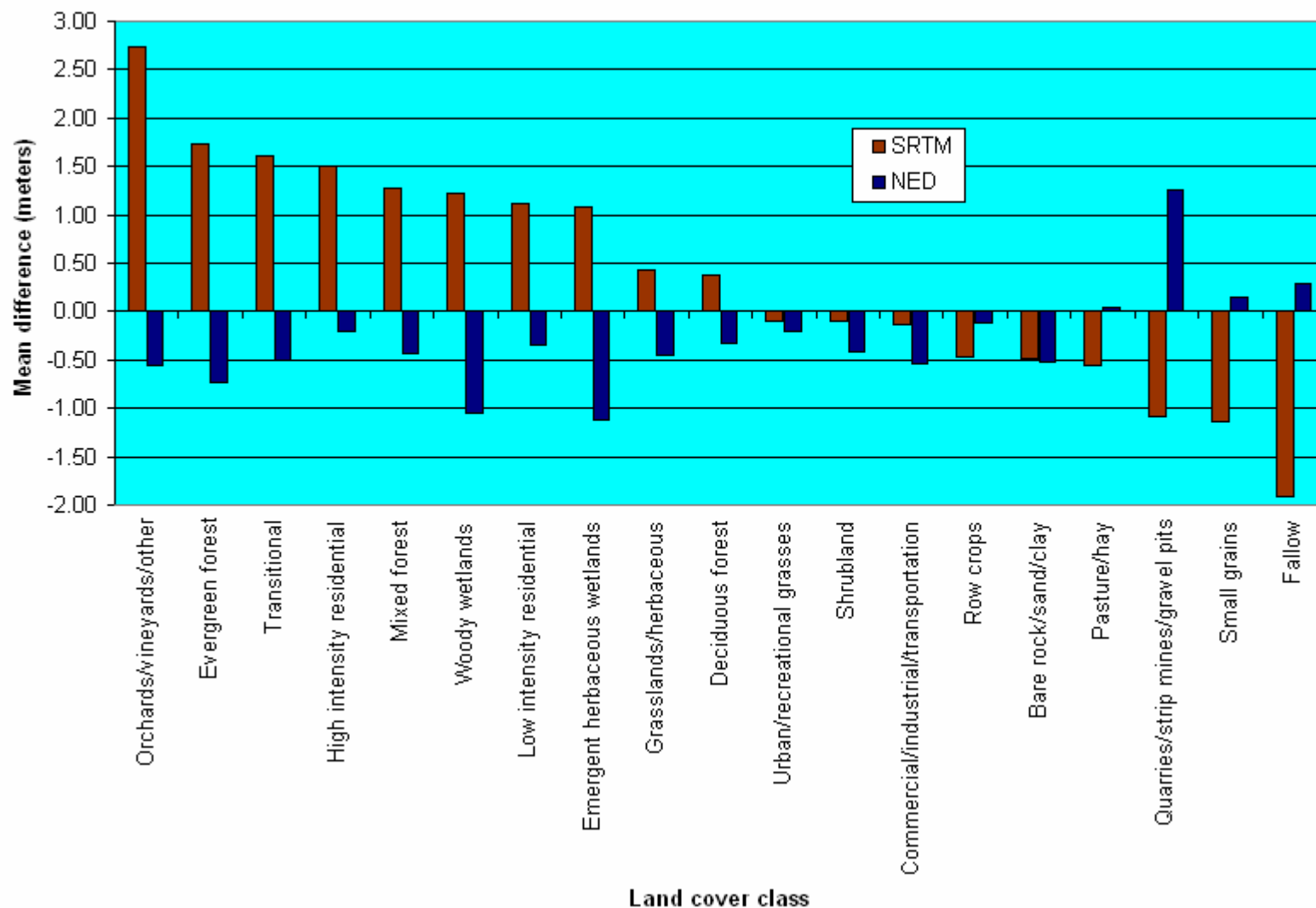
Statistics of Errors (meters) vs. NGS GPS Benchmarks

| DEM  | n      | Min.   | Max.  | Mean  | Std.<br>Dev. | <b>RMSE</b> | NMAS<br>(90%) | NSSDA<br>(95%) | 3<br>sigma |
|------|--------|--------|-------|-------|--------------|-------------|---------------|----------------|------------|
| SRTM | 13,305 | -31.11 | 30.31 | 0.09  | 3.52         | <b>3.53</b> | 5.80          | 6.91           | 10.57      |
| NED  | 13,305 | -42.64 | 18.74 | -0.32 | 2.42         | <b>2.44</b> | 3.99          | 4.75           | 7.27       |

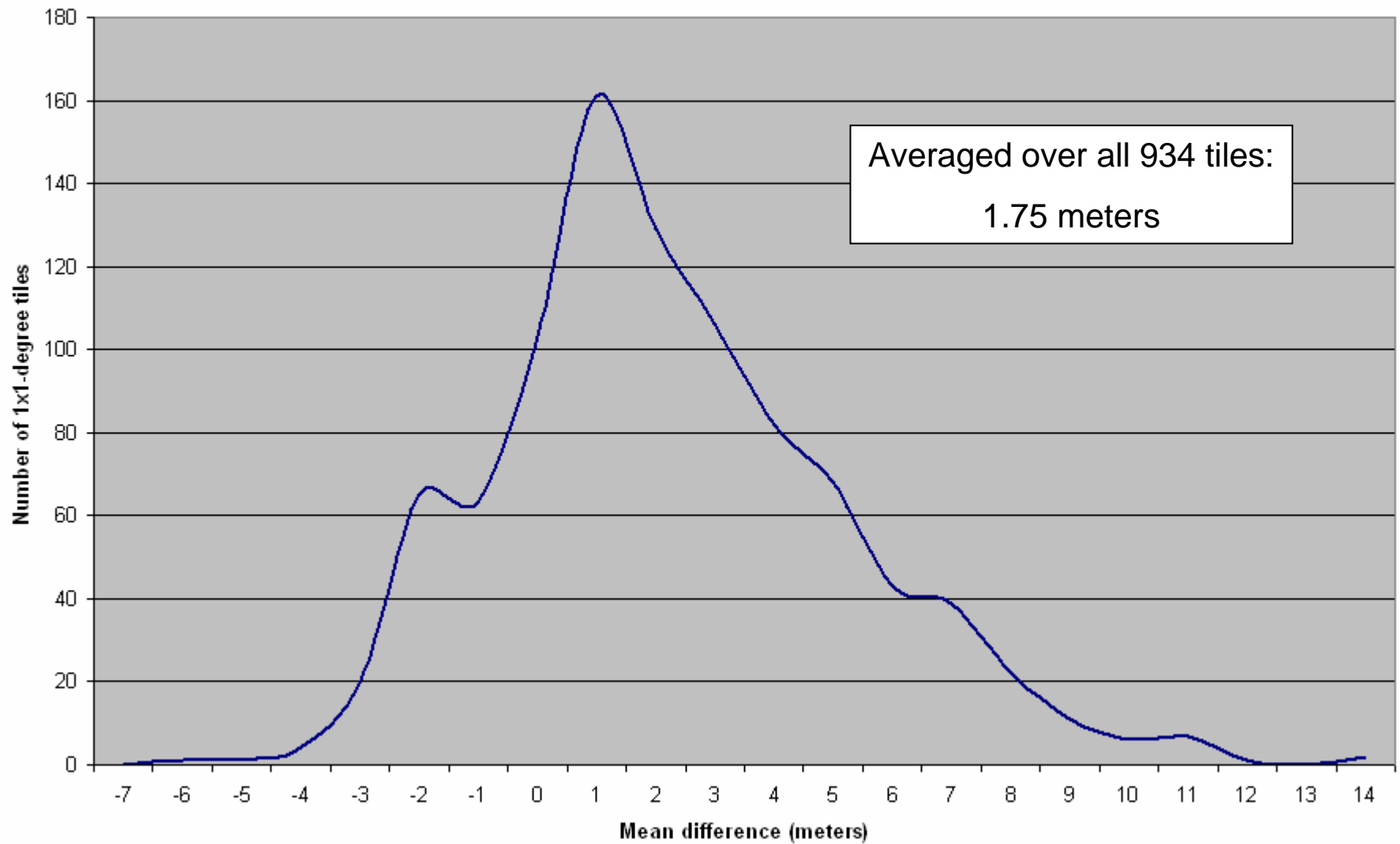
Absoute vertical accuracy by NLCD92 class



Absolute vertical accuracy by NLCD92 class

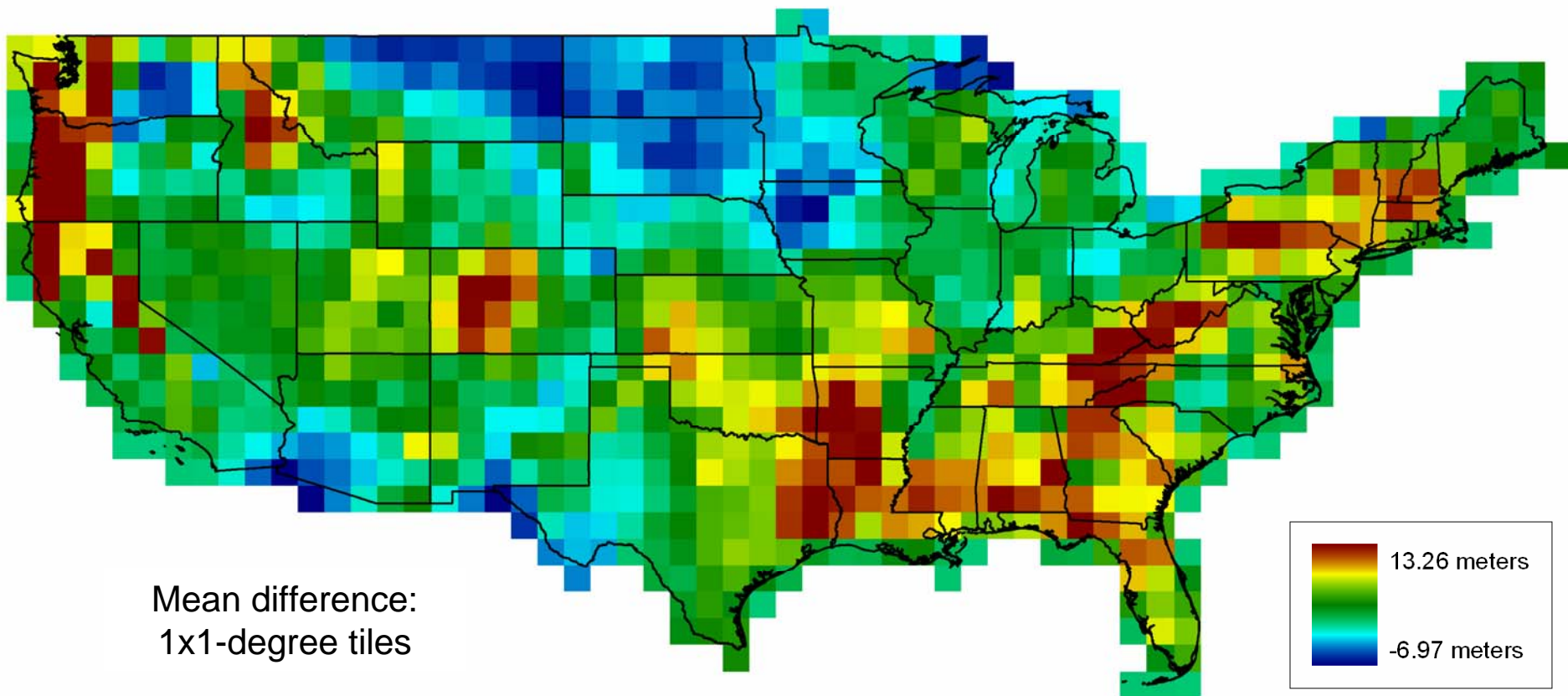


### Relative Comparison: SRTM - NED

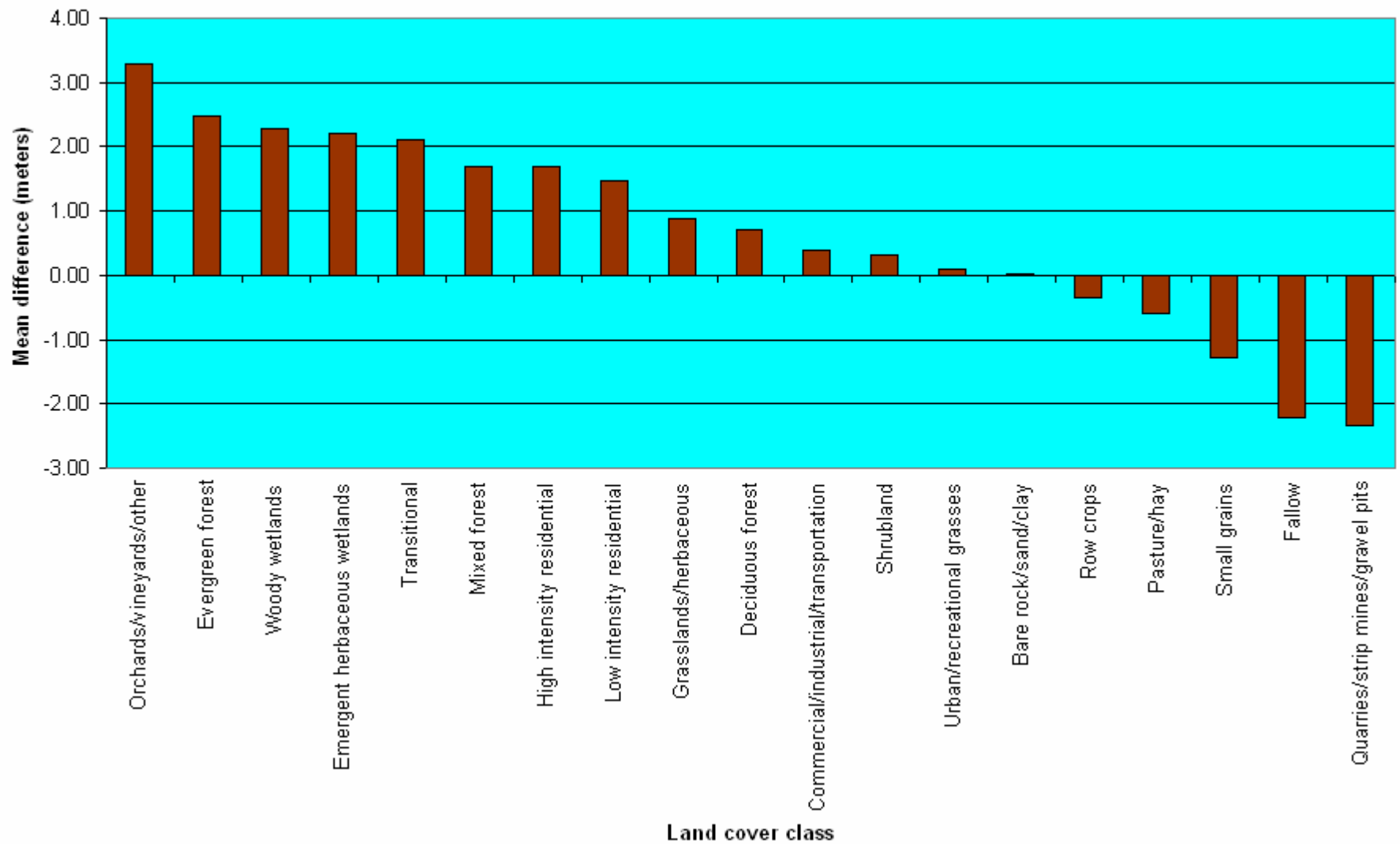




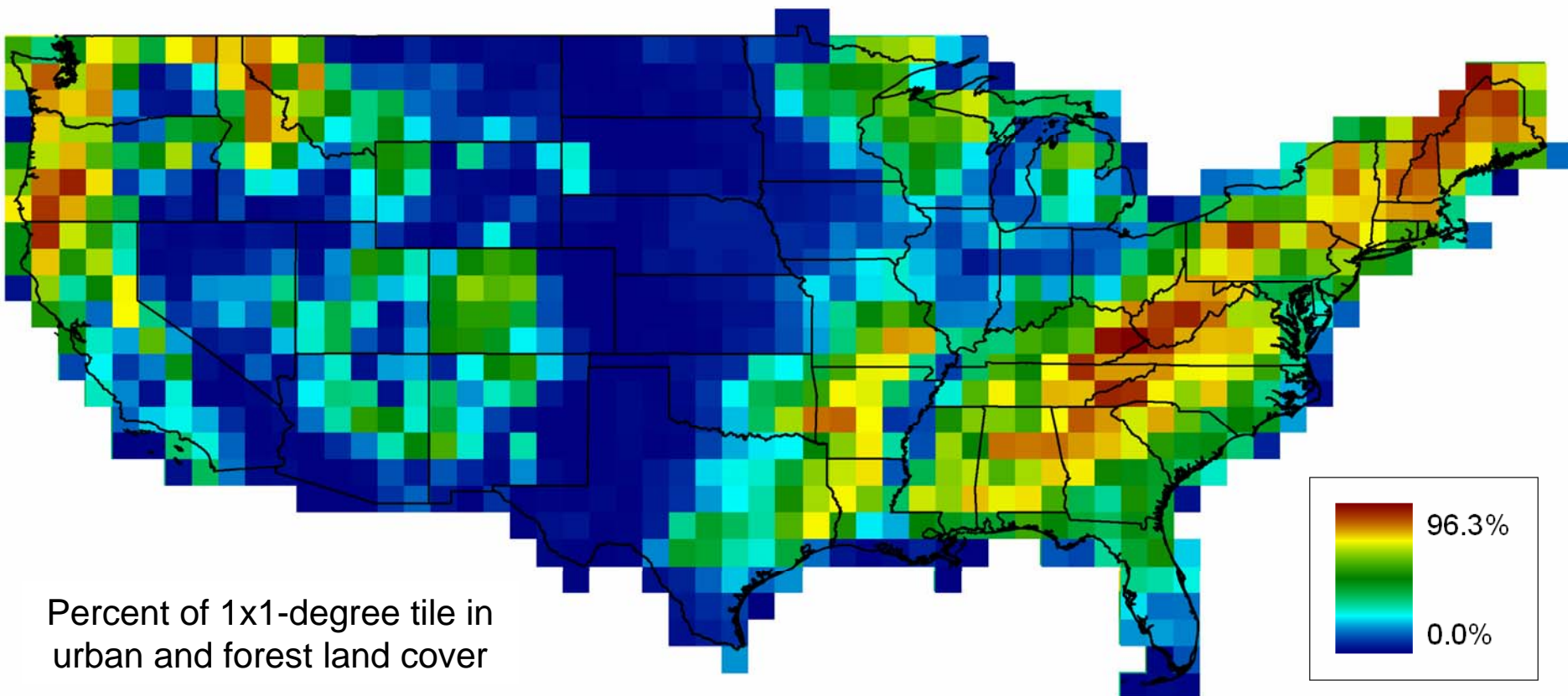
# *Relative Comparison: SRTM – NED*



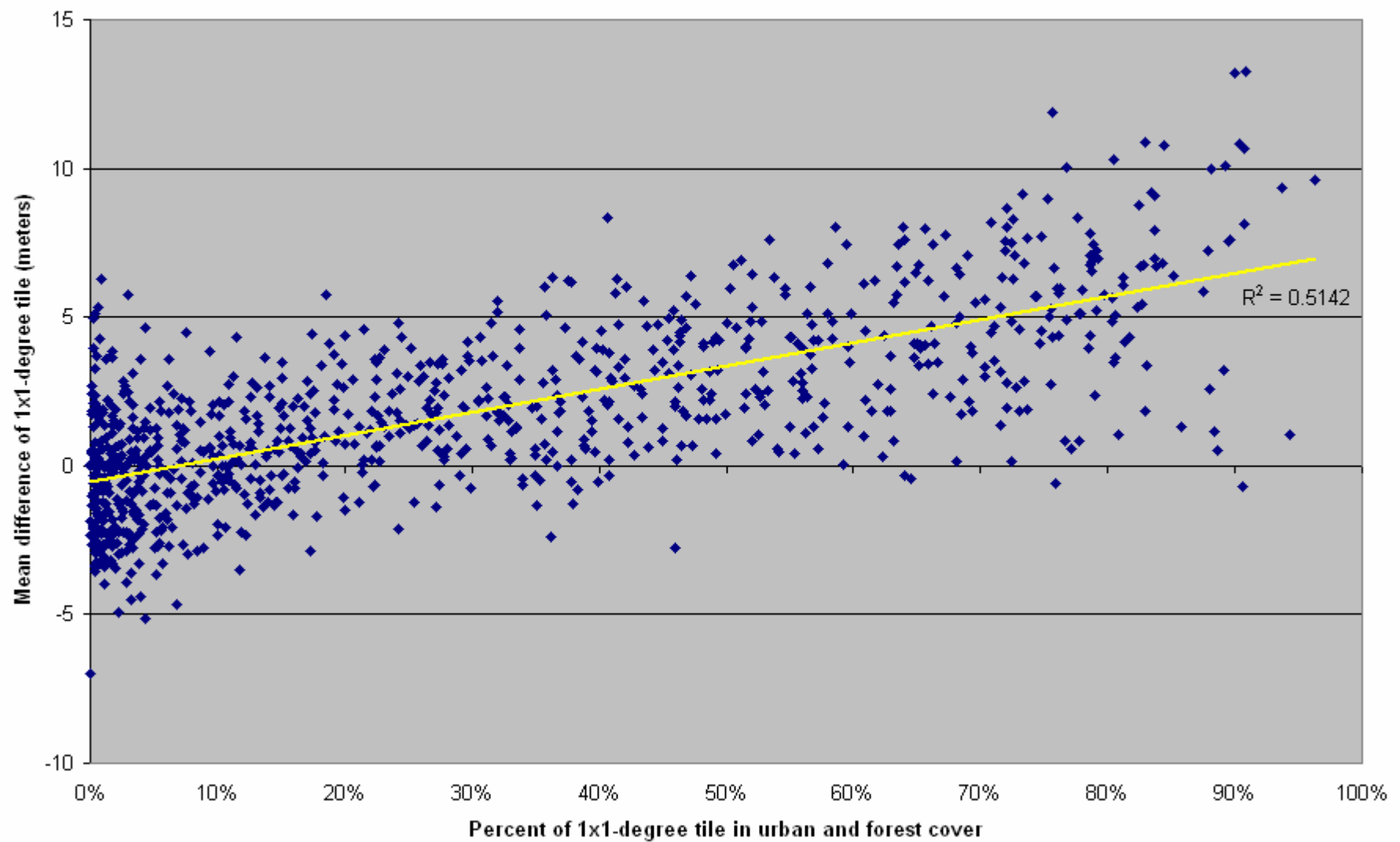
SRTM-NED differences by NLCD92 class



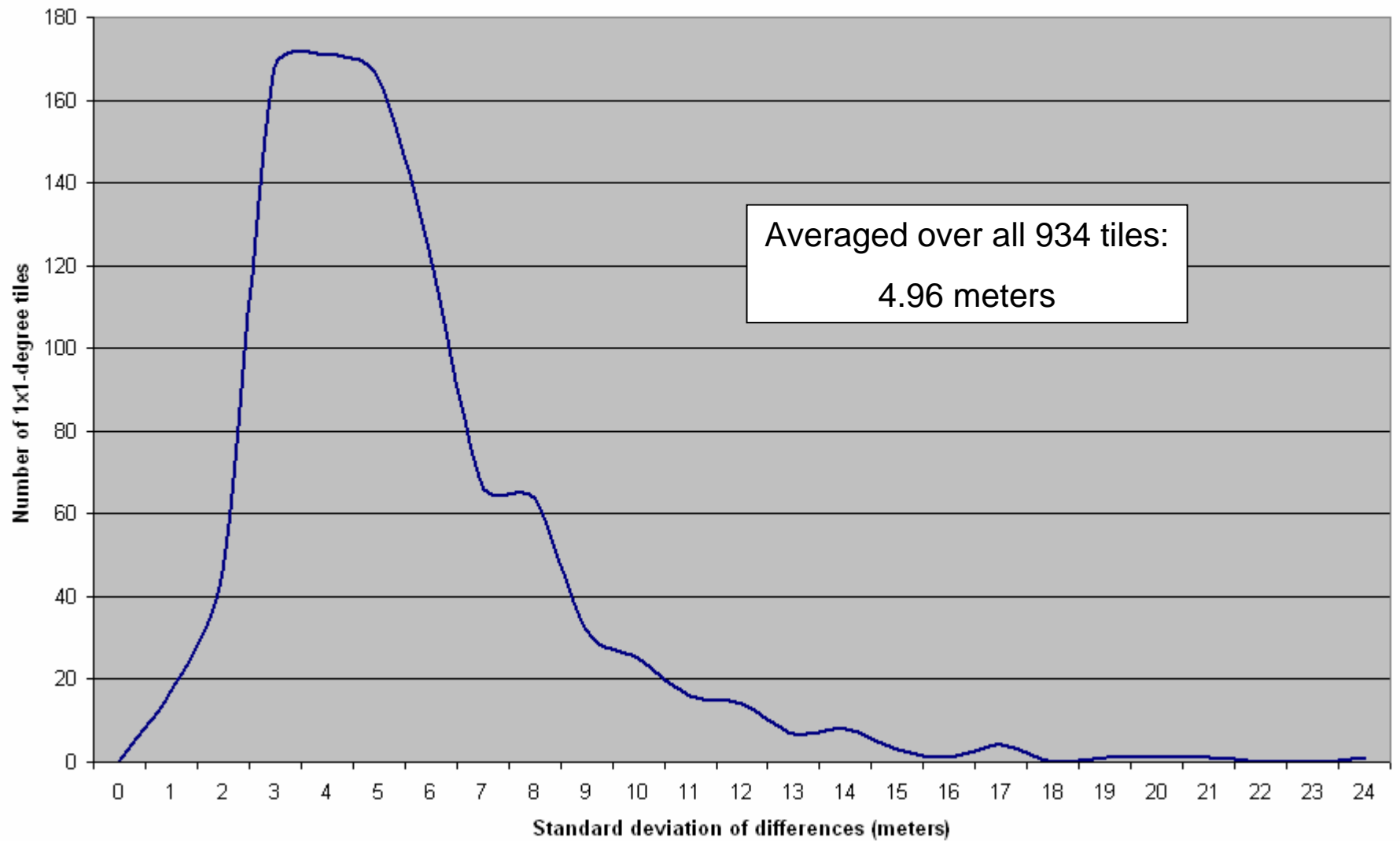
# *Relative Comparison: SRTM – NED*



SRTM-NED differences vs. Urban and forest cover

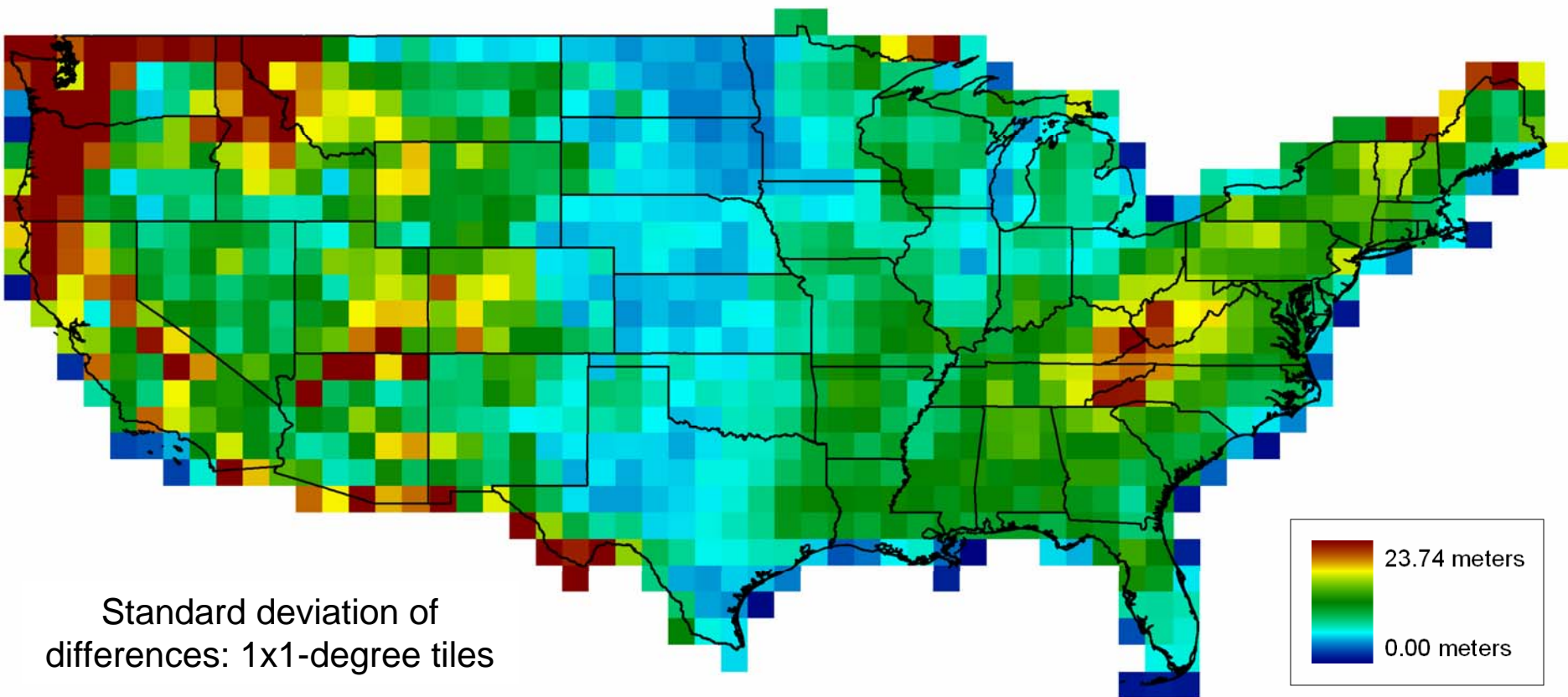


### Relative Comparison: SRTM - NED

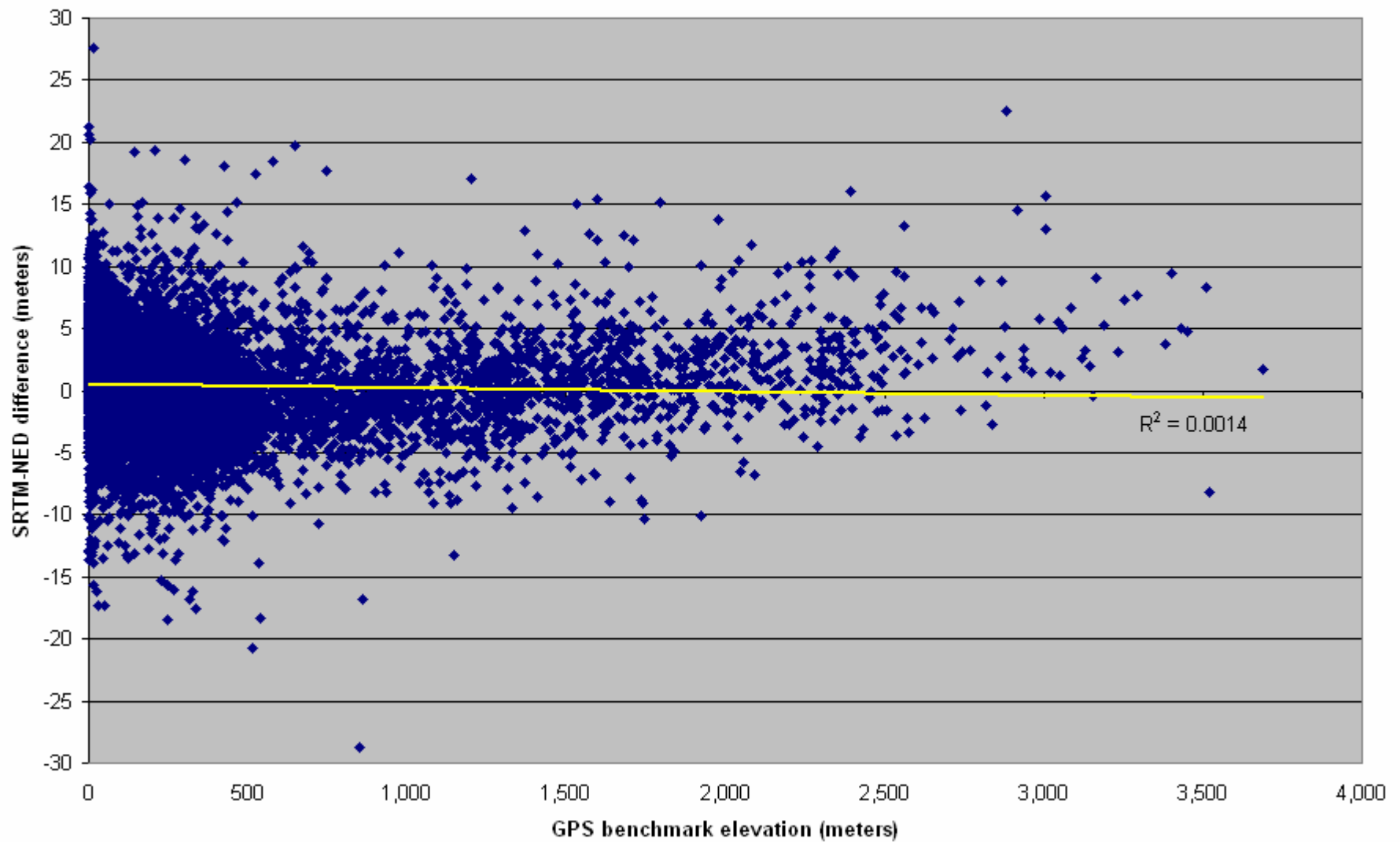




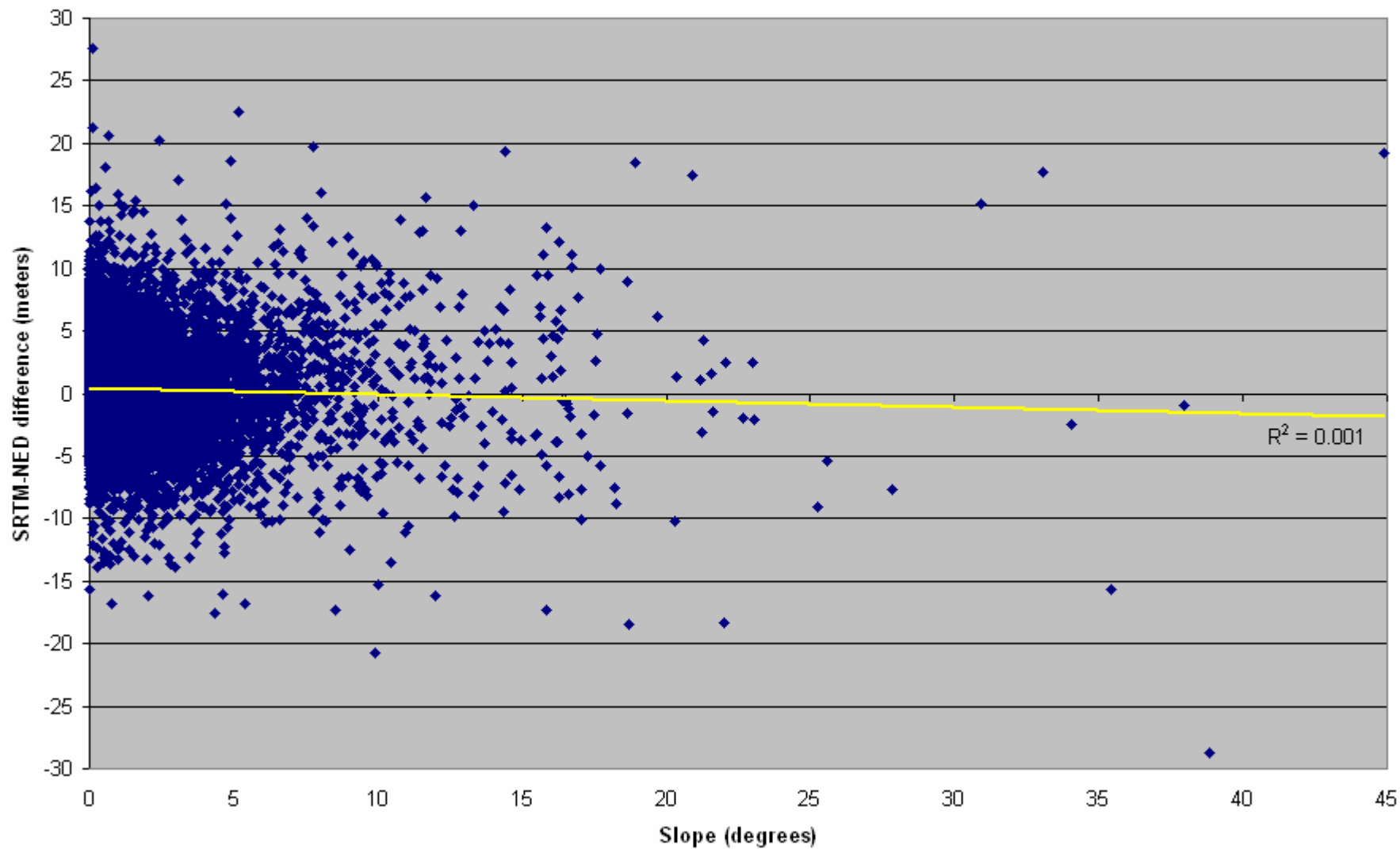
# *Relative Comparison: SRTM – NED*



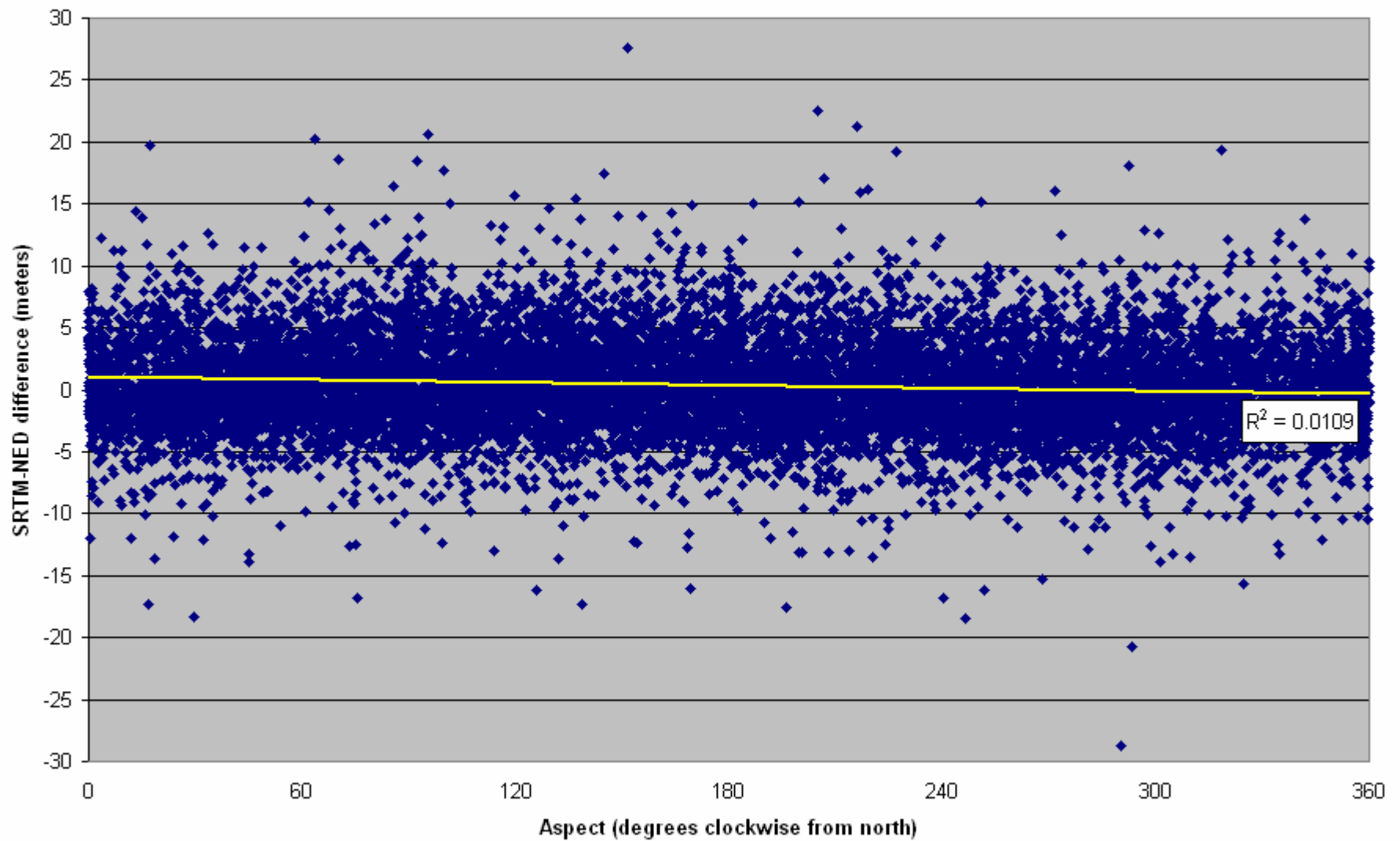
SRTM-NED differences vs. GPS benchmark elevations



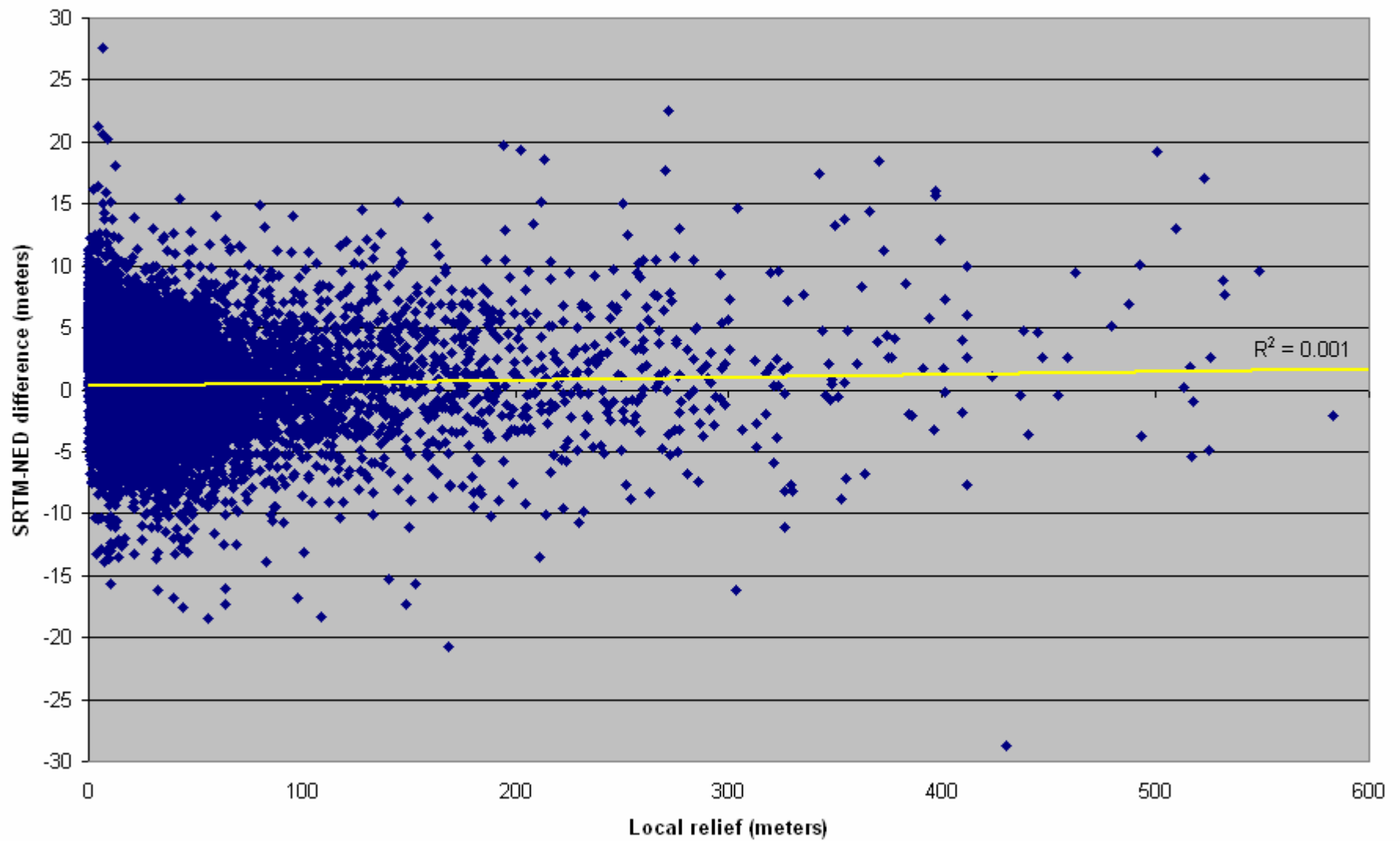
SRTM-NED differences vs. Slope



SRTM-NED differences vs. Aspect

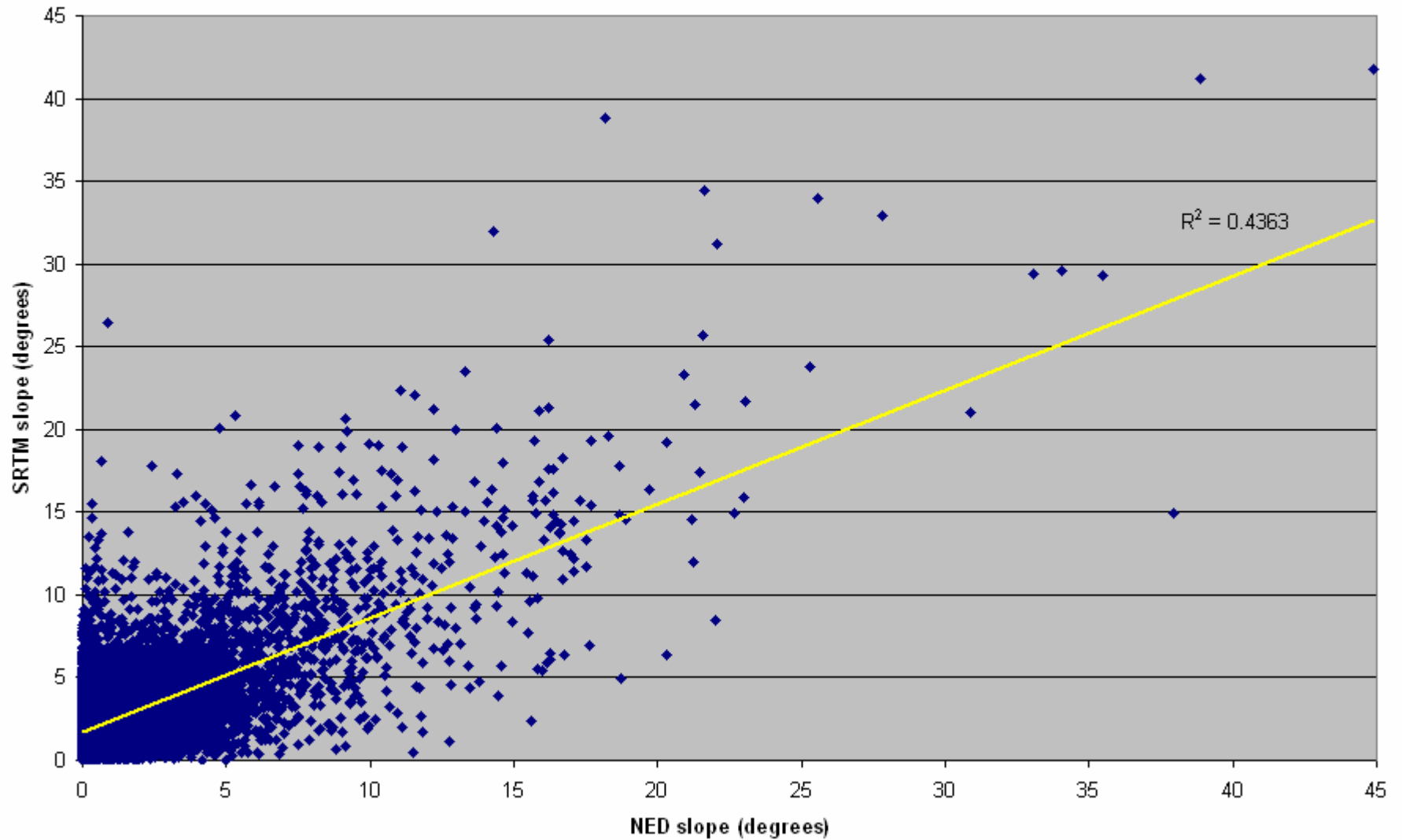


SRTM-NED differences vs. Local relief

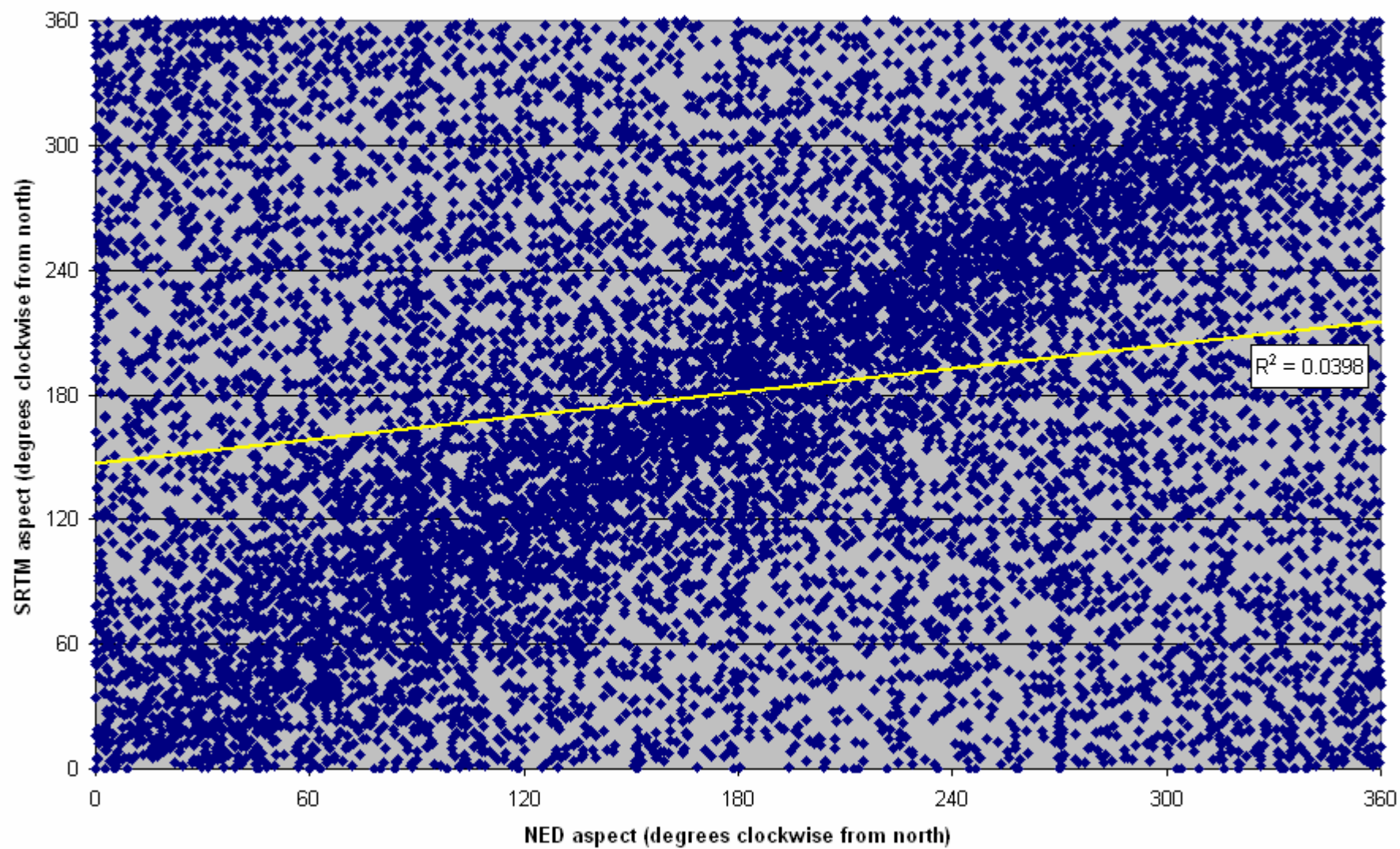




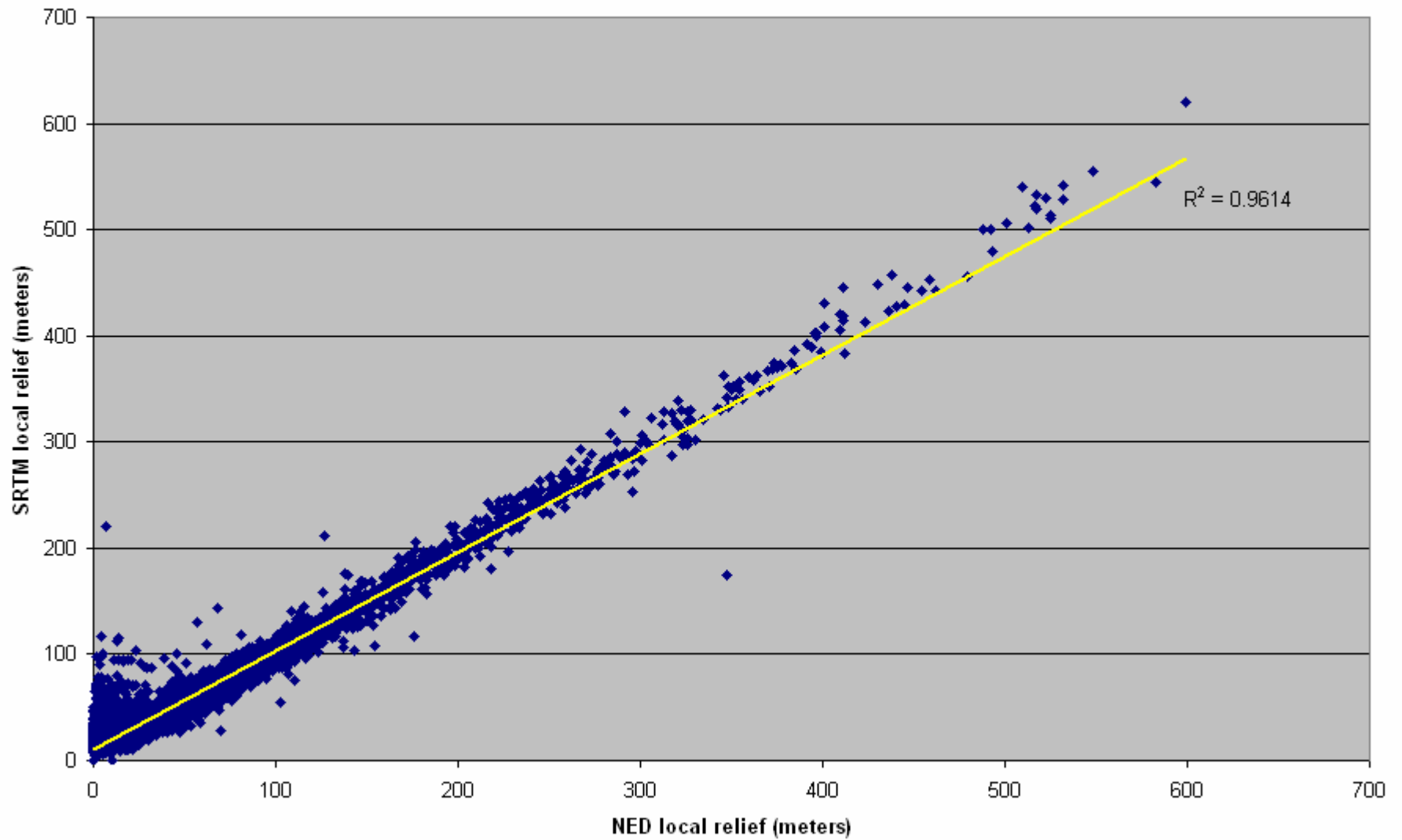
NED slope vs. SRTM slope



NED aspect vs. SRTM aspect



NED local relief vs. SRTM local relief

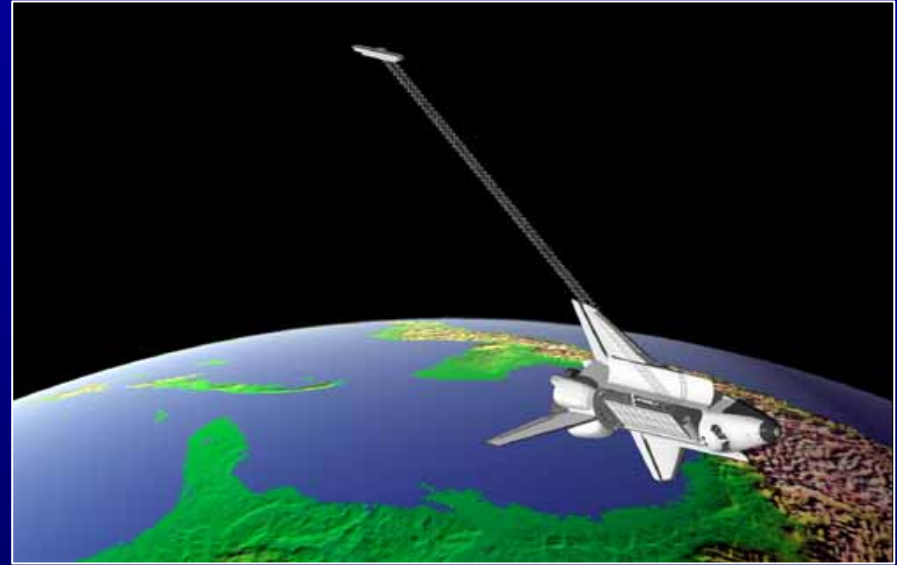


# *Use of Multi-temporal Elevation Data to Detect and Analyze Geomorphic Change*



*The National Elevation Dataset (NED)*

- 30-meter elevation data derived from over 55,000 topographic maps
- Historical: source dates range from 1923 - 1999



*Shuttle Radar Topography Mission (SRTM)*

- 30-meter elevation data derived from data collected during an 11-day mission in February 2000
- Recent: a topographic “snapshot” of the current shape of the surface

*NED and SRTM: a unique pair for geomorphic analysis*

# *SRTM – NED Comparisons to Detect Topographic Surface Change*

- After “co-registering” SRTM and NED elevation data, a simple differencing technique shows geomorphic changes that have occurred in the time interval between the source data collections
- For each cell, the older NED elevation is subtracted from the newer SRTM elevation:
  - Positive differences exist where SRTM is higher (elevation has increased – “fill”)
  - Negative differences exist where SRTM is lower (elevation has decreased – “cut”)

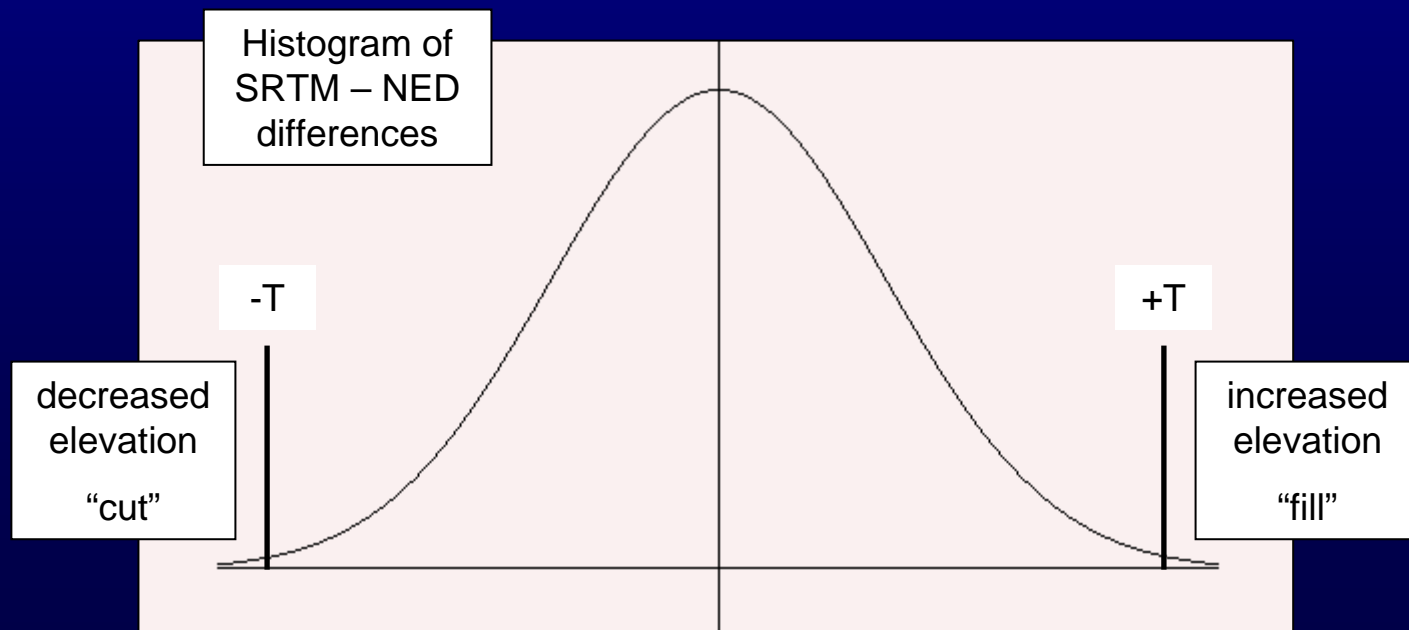
# *SRTM – NED Comparisons to Detect Topographic Surface Change*

- The differencing technique uses a “threshold” to detect *significant* surface changes
- The threshold,  $T$ , incorporates the inherent vertical accuracy of each dataset:

$$T = \pm 3 \left( \sqrt{(RMSE_{SRTM})^2 + (RMSE_{NED})^2} \right)$$

# *SRTM – NED Comparisons to Detect Topographic Surface Change*

- Differences not exceeding the threshold may be due solely to the combined effects of the inherent vertical error (uncertainty) of the SRTM and NED elevation data





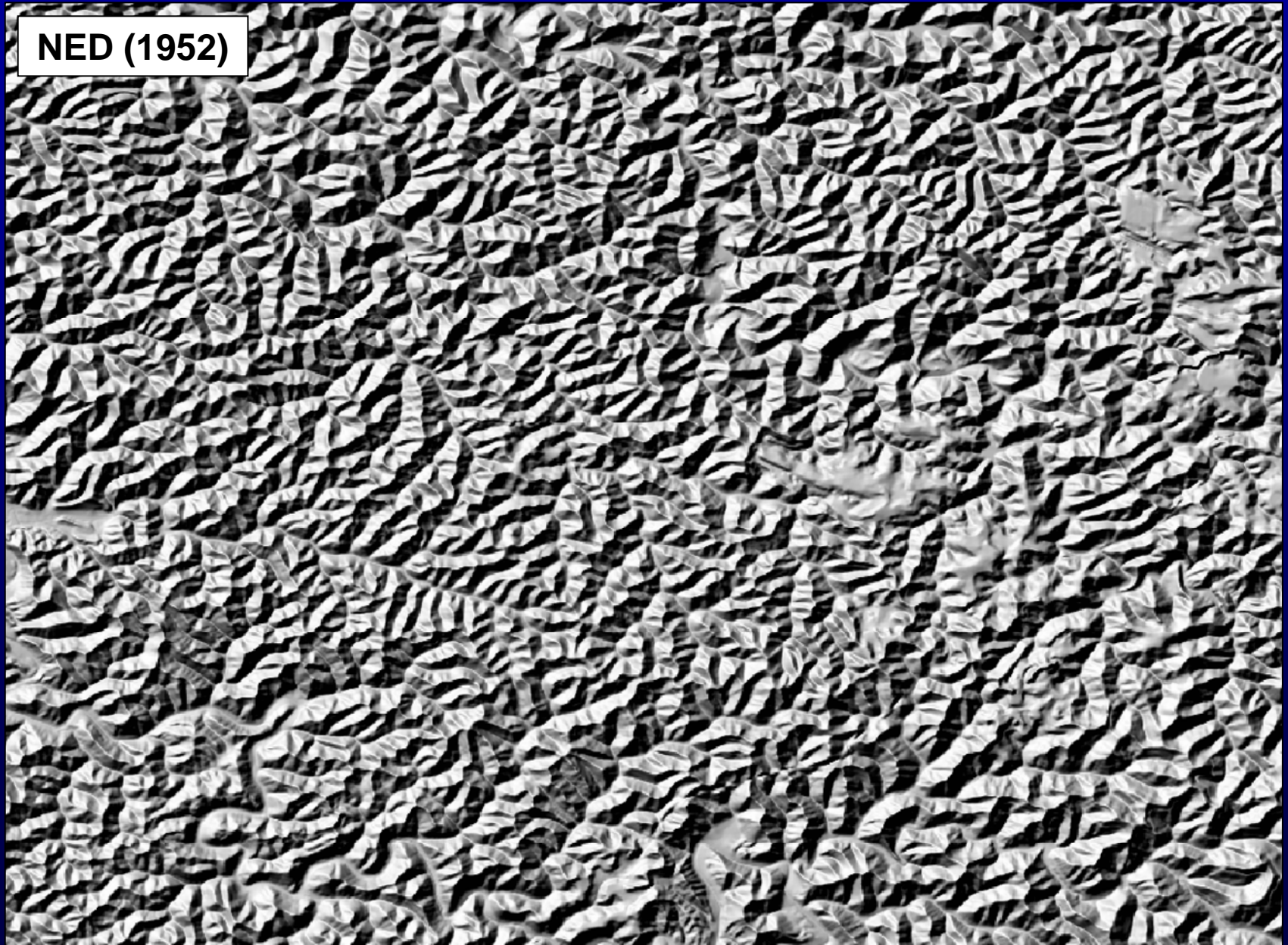
# Significant Change Threshold

- Absolute vertical accuracies (RMSE in meters), and surface change thresholds (meters):

| NLCD class                           | SRTM accuracy | NED accuracy | Diff. threshold |
|--------------------------------------|---------------|--------------|-----------------|
| Low-Intensity Residential            | 3.78          | 2.92         | $\pm 14.32$     |
| High-Intensity Residential           | 3.64          | 2.24         | $\pm 12.81$     |
| Commercial Industrial Transportation | 3.59          | 2.64         | $\pm 13.36$     |
| Deciduous Forest                     | 3.77          | 2.97         | $\pm 14.39$     |
| Evergreen Forest                     | 5.16          | 2.78         | $\pm 17.57$     |
| Mixed Forest                         | 3.68          | 2.71         | $\pm 13.72$     |

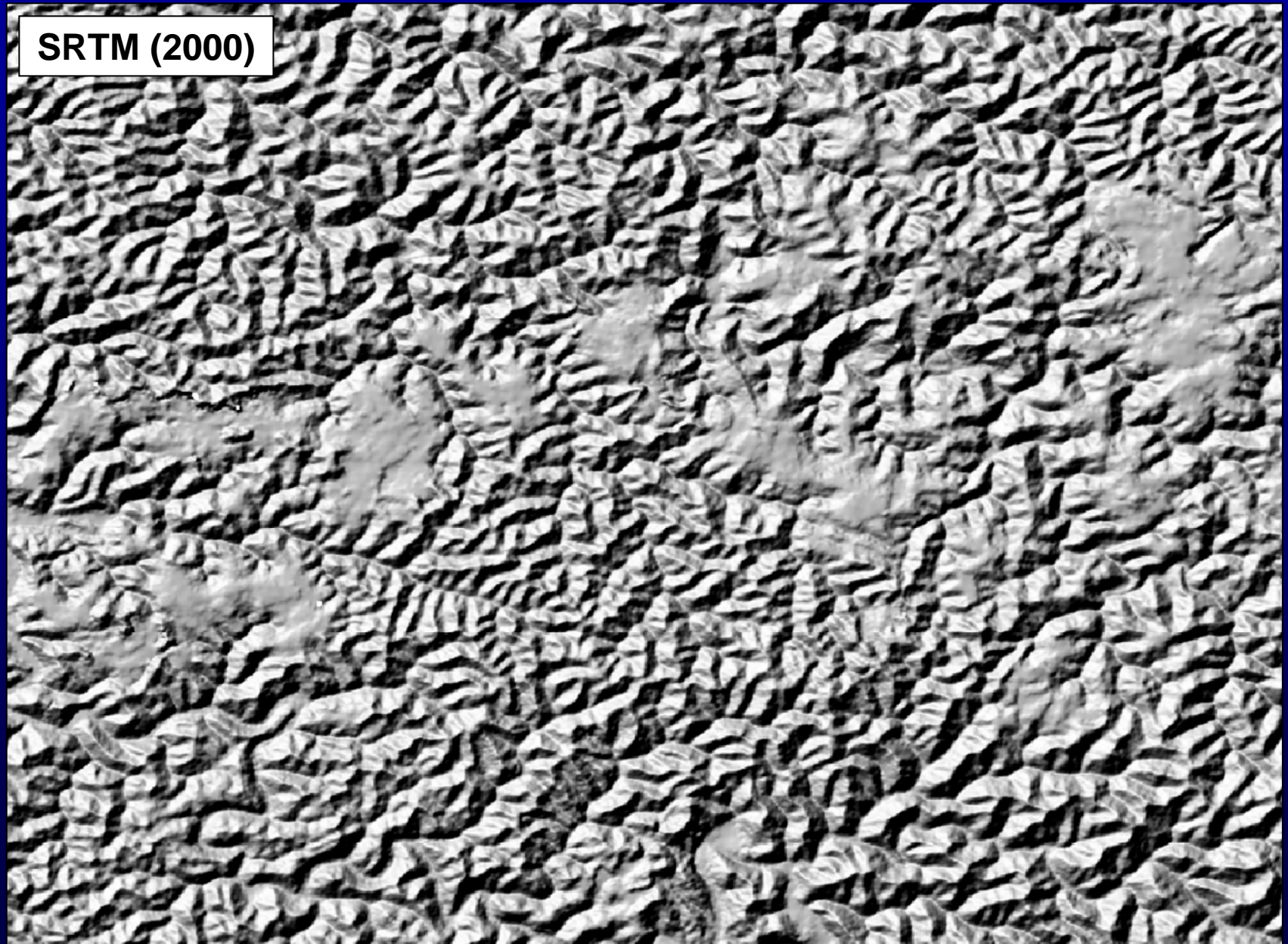
# *Eastern Kentucky: Surface Mines*

NED (1952)





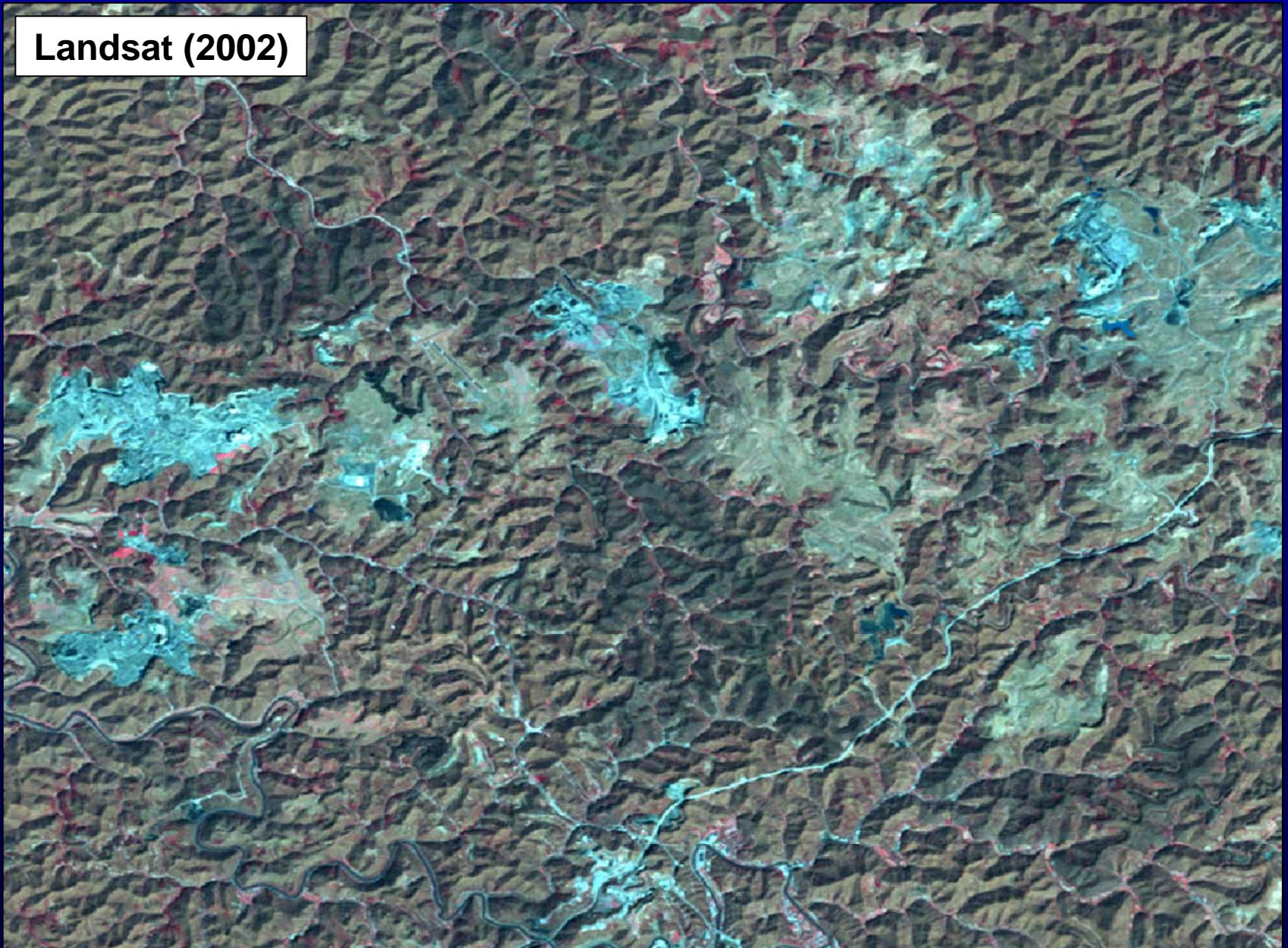
# *Eastern Kentucky: Surface Mines*





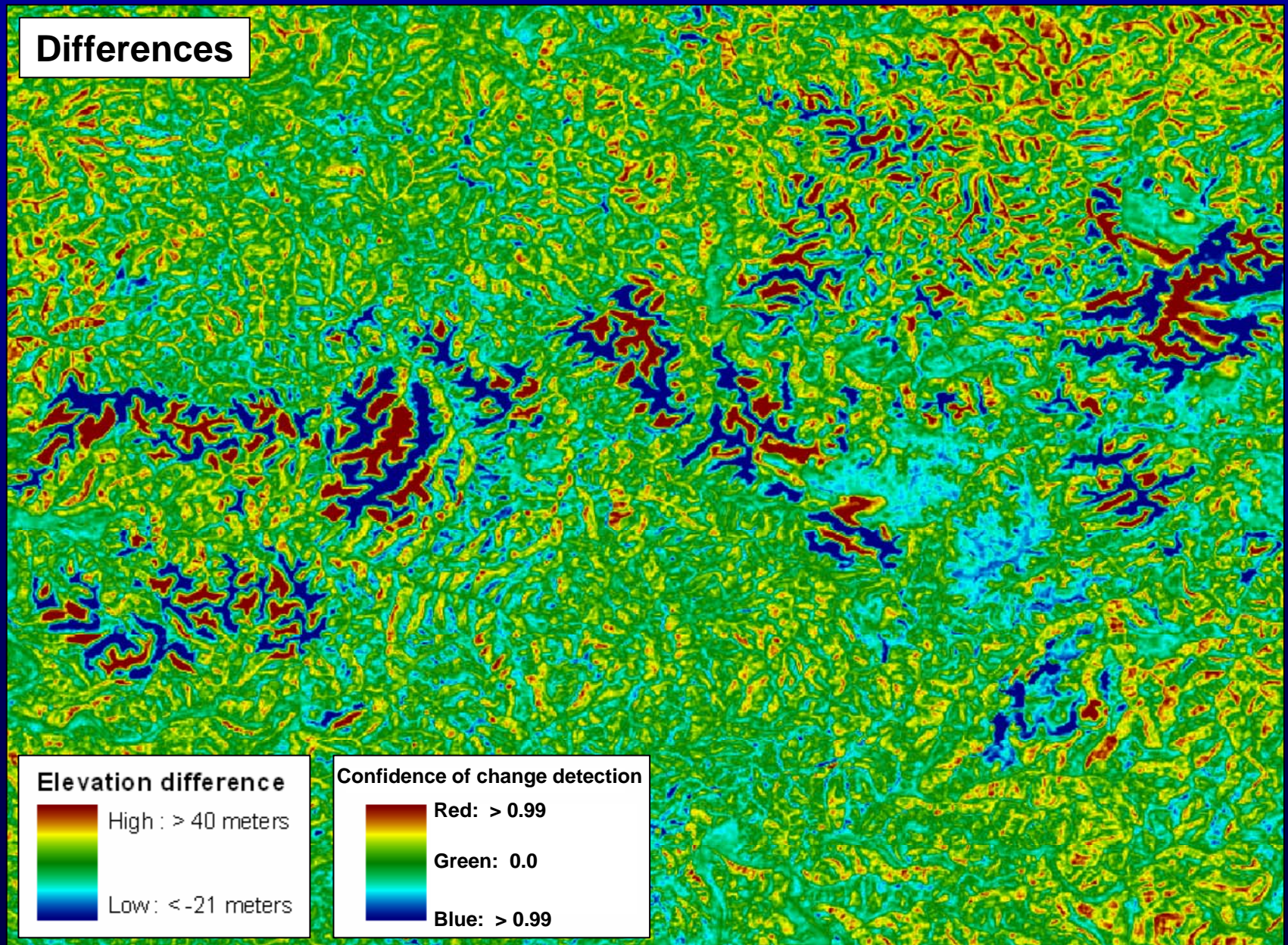
# *Eastern Kentucky: Surface Mines*

Landsat (2002)



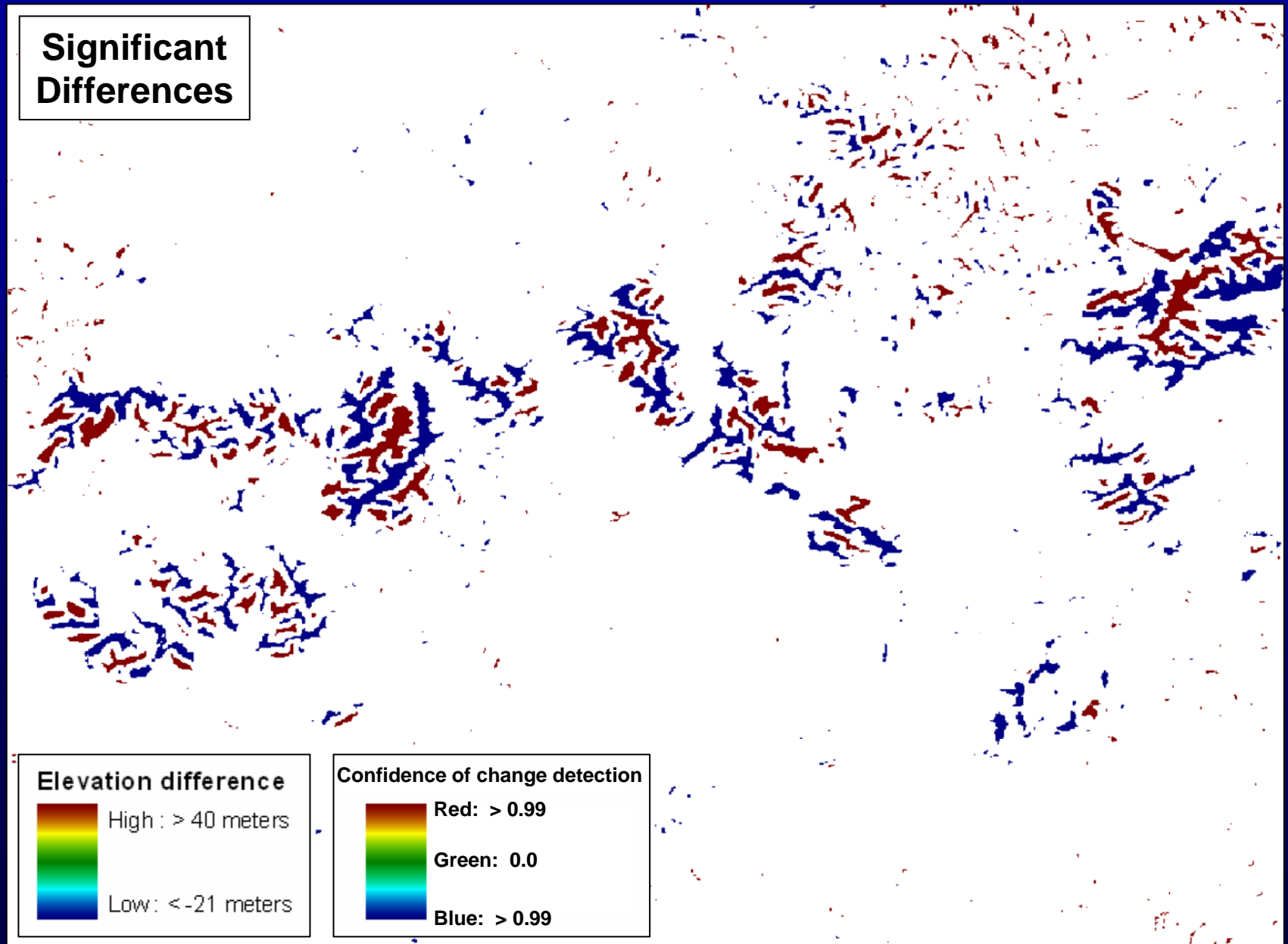


# *Eastern Kentucky: Surface Mines*

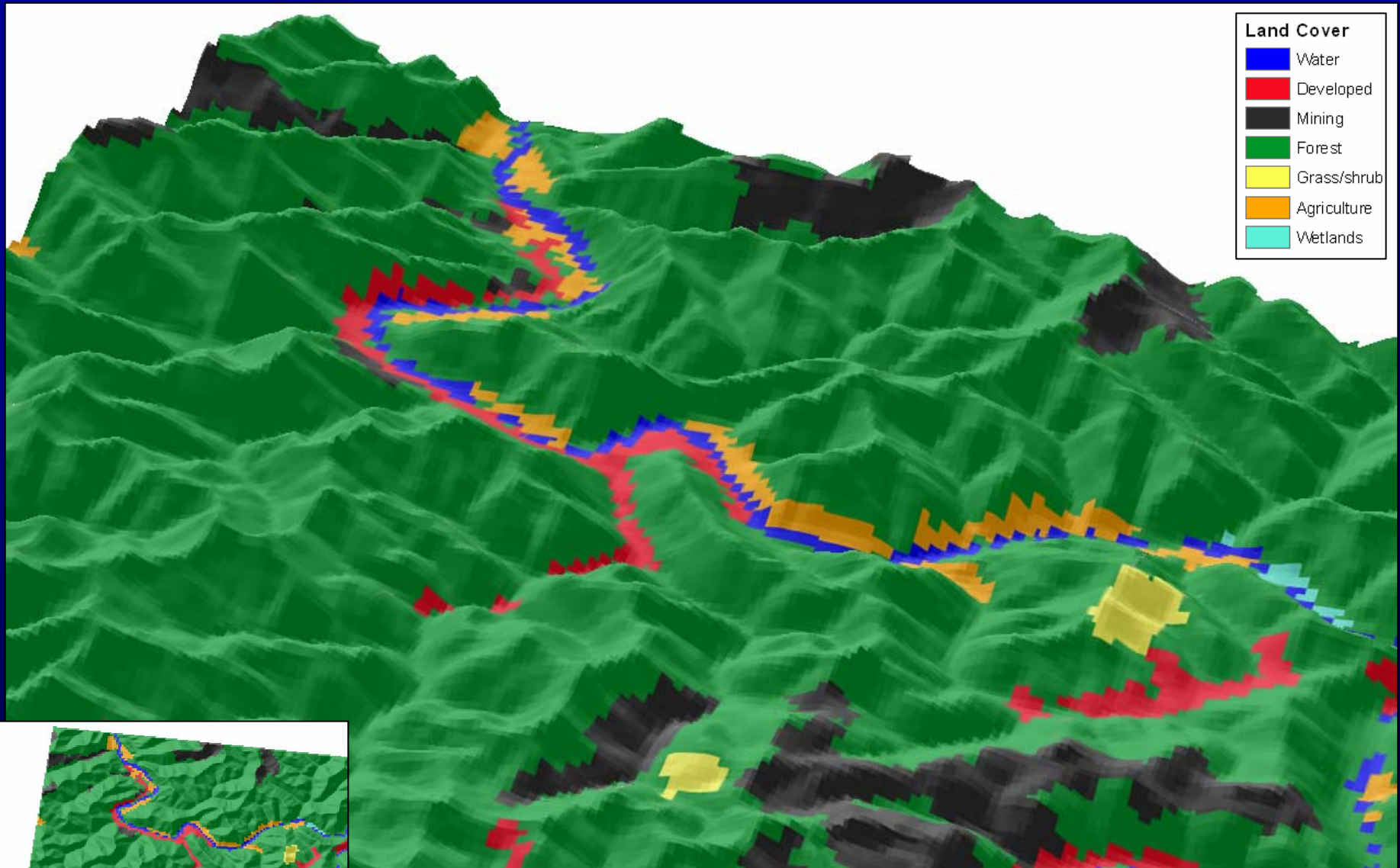




# *Eastern Kentucky: Surface Mines*

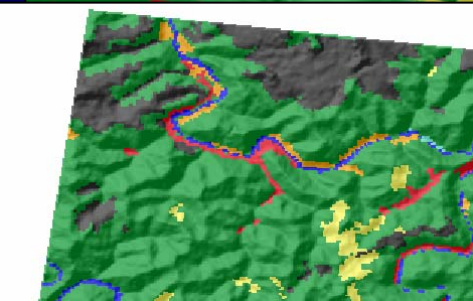
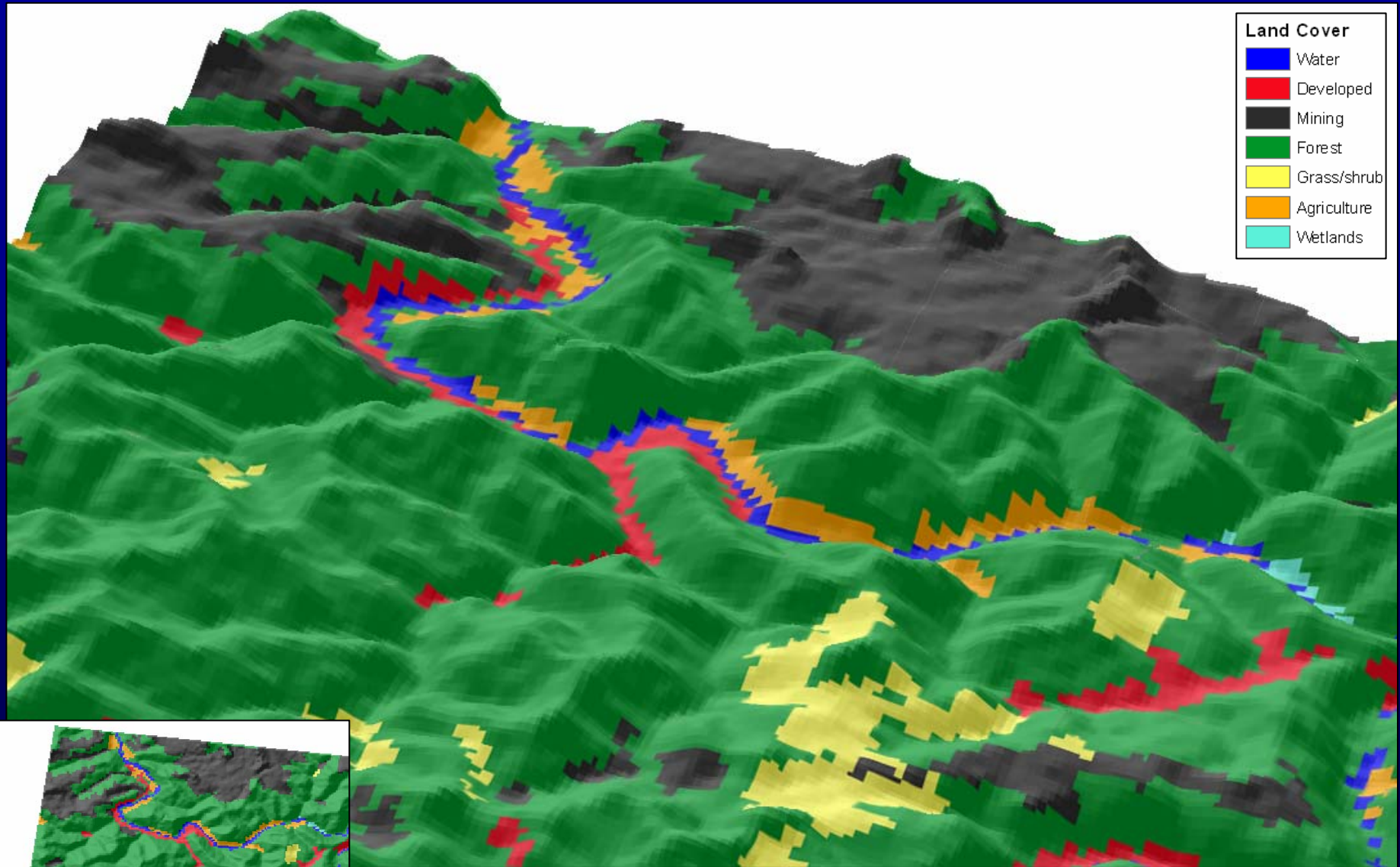


# *Land Cover and Topographic Surface Change*





# *Land Cover and Topographic Surface Change*



# Conclusions

- Absolute vertical accuracy of finished 1-arc-second SRTM data over the United States is 3.53 meters (RMSE), as measured against >13,000 GPS bench marks (compare with mission specification of 9.73 meters RMSE)
- Vertical errors in SRTM appear to be uncorrelated with elevation, slope, aspect, and local relief

# Conclusions

- Compared to NED 1-arc-second data over the United States, SRTM shows a mean difference (positive bias) of 1.75 meters, with the standard deviation of the differences at 4.96 meters
- Land cover appears to have an effect on absolute vertical accuracy and SRTM-NED differences
  - Positive bias and more uncertainty in SRTM data over forest and built-up areas

# Conclusions

- The high-accuracy recent topographic “snapshot” provided by SRTM is useful for large-area topographic change detection